FLUID AMPLIFIER STATE-OF-THE-ART REPORT.

VOLUME II-A:- BIBLIOGRAPHY

By M. J. Osborn

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FOREWORD

ABSTRACT

This bibliography updates (as an addendum) the Volume II Report (CR-102) which was issued December 3, 1963 under Contract NAS 8-5408 sponsored by the Marshall Space Flight Center. The search was restricted to pure fluid (no-moving-part) devices and supporting technology. This report cites 550 references of which 477 have been abstracted. A special effort was made to include references from outside of the United States. There has been a noticable increase in foreign fluidic literature.

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SUBJECT INDEX

INTRODUCTION

The bibliography was prepared by the General Electric Research and Development Center under Contract NAS 8-5408, sponsored by the Marshall Space Flight Center.

The search was restricted to pure fluid (no-moving-part) devices and supporting technology. The search was assisted by NASA (Scientific and Technical Information Division) and the Defense Documentation Center.

This bibliography updates (as an addendum) the Volume II report (CR-102) which was issued December 3, 1963. The report numbering system established in Volume II has been continued in Volume II-A. The majority of the titles cover the period since the last report. However, some earlier titles are included which did not appear in the previous issue.

There has been a tremendous increase in FLUIDICS* publications over the past two years. This report cites 550 references of which 477 have been abstracted. A special effort was made to include references from outside the United States. There has been a noticable increase in foreign FLUIDICS literature.

This bibliography is organized to present references by author in alphabetical order. (Section B) A subject index is also given with cross-reference identifications to the author index. (Section C) The title of each reference is given. An additional feature appearing for the first time is a corporate indexing of references. (Section D)

The volume includes only unclassified material.

The sources of information searched were:

Aeronautical Engineering Index
Aerospace Engineering Index
Aerospace Engineering Reviews and International
Aeronautical Abstracts
Annual Index of Journal of Fluid Mechanics
Applied Mechanics Review
Applied Science and Technology Index
Battelle Technical Review Abstracts
Chemical Abstracts
CIA Reports (Translations)
Defense Documentation Center

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*Fluidic - used in this report to connote only no-moving part fluid devices. Some groups are proposing the term "Flueric" for these devices and use the word Fluidic to include moving part devices used in conjunction with no-moving-part devices.

Engineering Index
General Electric Company - Main Library Card File
General Electric Company - Patent Office
General Electric Company - Technical Data Center
Index of NASA Technical Publications
International Aerospace Abstracts
Monthly Catalog of Russian Accessions
NASA Technical Publications Announcements
National Conference of Industrial Hydraulics
Nuclear Science Abstracts
Russian Patent Abstracts (General Mechanical and Electrical)
Science Abstracts (A) Physics
Translation Monthly
U.S. Government Research Reports

A-038

Adams, R. B. (Moore Products Company)

APPLICATION OF FLUIDIC VALVES

ASME paper 65 WA/PID-12 presented at the Winter Annual Meeting Chicago, Illinois, November 7-11, 1965

Fluidic diverting valves are a radically different development for flow control which do not have any valve stem, plug, or packing. They do not require a large actuator to operate them. It is because of these differences that their application requires a departure from the thinking used for conventional valves. The principle of operation of two-position diverting, proportional diverting, oscillating diverting, and liquid-level control valves is described. A review is made of factors determining the type of application for which fluidic valves are suited. The basic approach used to apply these valves is illustrated with some applications.

A-039

Adams, R. B. (Moore Products)

CONTROL APPARATUS

U. S. Patent No. 3,187,763 dated June 8, 1965, filed December 17, 1962

The principal object of this invention is to provide a proportioning valve in which the proportional division of fluid is unaffected within limits by the outlet pressure connection pressure conditions.

A-040

Adams, R. B. (Moore Products)

TRANSDUCERS

U. S. Patent No. 3,173,437 dated March 16, 1965, filed September 22, 1961

This invention relates to transducers and more particularly to transducers having a pneumatic balancing circuit either of the force balance or of the motion balance type. It is the principal object of the present invention to provide improvements in transducers having pneumatic balancing circuits with nozzles in which changes in the supply pressure are effective in the nozzle but are not effective in the transmitted output pressure.

A-041

Airey, L.; Reeves, D.; Inglis, M. E. (National Gas Turbine, Establishment U.K.).

THE FLUID OSCILLATOR AS A TEMPERATURE SENSOR

Paper given at the First Conference on Fluid Logic and Amplification, September 9-10, 1965. Sponsored by the British Hydromechanics Research Association and the College of Aeron. Cranfield, England.

A-042

Aizerman, M. A.

PNEUMATIC AND HYDRAULIC AUTOMATION

DDC Report AD-618061 (Foreign Tech Division, WPAFB, FTD-TT-65-169)

Unedited rough draft translation of Mono. Pnevmo - 1 Gidroavtomatika, Moscow, 1964. June, 1965

Universal system of elements for industrial pneumatic automation (USEPPA); pneumatic relay circuits; regulators and optimizers; transducers and converiers; centralized monitoring and control systems; hydraulic drives; general problems of hydraulic automation.

A-043

Akmenkalns, I. G.; Pasternak, E.; Schaffer, R. R.

PNEUMATIC TO ELECTRIC TRANSDUCERS

IBM Technical Disclosure Bulletin, Vol. 5, No. 7, December, 1962

These transducers provide electrical output signals denoting the logic state of a fluid amplifier type logic device. The transducing system employs either temperature-sensitive diodes or pressure-sensitive resistors.

A-044

Alblas,* J. B.; Cohen, H. G.

THE DEFLECTION OF TURBULENT JETS BETWEEN BOUNDING WALLS

Proc. of Koninkl, Nederl Akademie Van Witenschappen, Amsterdam, Series B67, No. 3, 258-288(1964)

The behavior of a turbulent jet between bounding but not contacting walls is investigated as a hydrodynamic model for one stage of the flow in a fluid jet amplifier. For the steady flow, by means of free jet mixing theory, the entrainment in the bounded regions exterior to the jet is determined. A formula for the Coanda effect that exhibits the mixing properties is developed. This steady flow is then perturbed by the application of pressure differentials across the jet. The deflection of the jet is determined as a function of the applied pressures, the wall angle, and other flow parameters.

*Technological University, Eindhoven.

A-045

Angrist, S. W.

FLUID CONTROL DEVICES

Scientific American, December 1964, Vol. 211, Pages 81-88

Two different techniques of fluid control are being investigated. One called "proportional control" and the other a more complex and versatile system. Both are described. The fluid-control concept is still in its infancy, with little practical use made of it so far. One of the problems is miniaturization of the fluid element so that it will compare with an electronic or a mechanical component. Most promising technique for doing this seems to be optical fabrication. Research is going forward toward three main goals (1) Understanding the basic processes that underlie the operation of fluid amplifiers (2) Developing methods of producing them in compact size and in quantity at low cost and (3) finding the applications for which they will be most suitable.

A-046

Angrist, S. W.; Osterle, J. F.; Rondeau, W. T.; Young, F. J.

UNCONVENTIONAL METHODS FOR INFLUENCING FLUID FLOW

See author Osterle, J. F.

A-047

Anonymous

AMPLIFIERS THAT RUN ON LIQUID DIET

Business Week, November 7, 1964, Pages 130-132

Working on gases and liquids, fluid amplifiers do much the same job of controlling energy as transistors do in electronic circuits -- and they may become cheaper. Fluid amplifiers are at about the same stage of development that transistors were in 15 years ago, breaking into use only in systems where their special qualities count.

A-048

Anonymous

FLUID AMPS RUN LOCOMOTIVE

Control Engineering, July, 1965, Page 23

Pneumatic logic elements control excitation and contactors on a diesel-electric. Further on-board and wayside applications loom.

A-049

Anonymous

FLUID DYNAMIC SOLUTIONS TO DATA PROCESSING AND SERVOTECHNICAL PROBLEMS

DISA Information, January, 1965, Pages 7-10

Description of new flow units which use jets of gases and liquids as the operating element in different applications. The flow units, known as pure fluid systems, have been found to possess numerous applications. It is noted that, while pure fluid systems will sometimes be the only solution where operations of control and calculation are to be performed under unusually high or low temperatures or heavy radiation, it is still very far from clear how widespread application these systems will find under normal physical conditions. For one thing, for the simple reason that the limitations of the functioning of pure fluid systems have not yet been sufficiently explored. Certain applications, however, seem to suggest themselves readily: for servosystems where the error signal is an air pressure or a liquid pressure. This application obviates the need for converting pressures into electric signals and vice versa, and the response speed for pure fluid systems will in most cases be entirely adequate.

A-050

Anonymous

FLUID JET CONTROL DEVICES AT THE MOSCOW INSTITUTE OF AUTOMATION

Control, November, 1963, Pages 263-265

A-051

Anonymous

FLUID TECHNOLOGY HELD READY FOR GROWTH INTO MIGHTY RIVER

Electronic News - January 11, 1965

A-052

Anonymous

HOT GAS CONTROLS WAITING IN THE WINGS

Control Engineering, July 1962, Pages 65-66

    Hot gas controls of one kind or another loom as a prime means of controlling future missiles and space vehicles. Servoactuator types will be useful for manipulating aerodynamic control surfaces on surface-to-surface missiles and for thrust nozzle vectoring on other vehicles. In more general use and under more intensive development are relative control systems.

    The Martin Co. is leading one development of an "all-pneumatic missile" which involves pneumatic computation, hot gas-driven gyros and pneumatic accelerometers, pneumatic signal transmission and hot gas actuators.

A-053

Anonymous

MEMORY FOR A PNEUMATIC DIGITAL COMPUTER

Computers and Automation, Vol. 10, July, 1961, Page 6

    A laboratory prototype of a component for a pneumatic digital computer is under design by the Kearfott Division, General Precision, Inc., Little Falls, N. J. This component contains (2) bistable elements or flip-flops and the capacity for 4 more. The "piping" consists of holes drilled in the layers. Connections to the flip-flops are made through the screwholes at the top and bottom. The component is created by clamping the layers together.

A-054

Anonymous

NASA WILL INVESTIGATE PNEUMATIC COMPUTERS

Electronics, May 10, 1963, Page 7

NASA'S Marshall Space Flight Center is expected to award a contract shortly, to study pneumatic computer techniques. The contractor will study concepts for computing with multiple controlled jets and for improving the basic binary flip-flop based on the single switchable jet.

A-055

Anonymous

NEW LOGICAL DEVICES

Data and Control, January, 1964, Pages 32-36

A-056

Anonymous

NEW PNEUMATICS - PNEUMATICS AND RUSSIAN STEEL CONTROL PROMINENT AT IFAC

Control Engineering, October, 1963, Page 29

A range of complex control systems are planned for all sections of the Soviet Steel Industry. A survey paper presented at the IFAC (International Federation of Automatic Control) Basle Congress by Dr. A. Ya Lerner of Moscow's Institute of Automatics and Telemechanics reveals that optimizing systems are being planned for sintering plants and that installations are under way for computer-controlled converters and heat controlled systems in open hearth furnaces.

A-057

Anonymous

NO MOVING PARTS FOR FLUID AMPLIFIER

Product Engineering, March 14, 1960, Page 17

Oil or air circuits may soon compete for control applications previously thought suitable only for electronic and electrical controls. Reason: a simple new fluid amplifier just unveiled at the Army's Diamond Ordnance Fuse Laboratories. Development of the amplifier, which uses either a gas or liquid and has no moving parts, is a fundamental break through, according to Richard S. Morse, director of Research and Development for the Dept. of the Army.

A-058

Anonymous

PNEUMATIC ANALOG CONTROLLER DEVELOPED BY BAILEY METER

Computer and Controls, September 16, 1963, Page 31

A-059

Anonymous

PUFF-BLOW CONTROLS AID DISABLED

Control Engineering, October, 1963, Page 26

A pneumatic control system developed by the Electromechanical laboratory
of the Stoke Mandeville Hospital, Buckinghamshire, England, allows patients
disabled by polio or spinal injuries to operate typewriters or make phone calls.
Even with substantial paralysis, the patient's mouth still functions as an efficient
pneumatic pulse source giving up to 10 pressure-suction cycles per second at 7-14
cm. Hg. Specially designed diaphragm operated switches convert the patient's puffs
or sucks into electrical signals to operate bedside equipment.

A-060

Anonymous

PURE FLUID AMPLIFICATION

Electromechanical Design, June, 1960, Pages 60-61

A-061

Anonymous

PURE FLUID AMPLIFIER JOINS TUBES, TRANSISTORS AS BASIC ELEMENT

Electronic Design, March 16, 1960

A new principle of amplification, replacing vacuum tubes and transistors in
some applications has been developed at the Diamond Ordnance Fuse Laboratory,
Washington. The basic amplifier is nothing more than a block of metal or hard
plastic, with passages for the flow of a fluid. There are no moving parts. Operation
is possible in temperatures ranging from near cryogenic to white heat. Shock,
vibration, humidity and operating life should be a minor problem
according to the Laboratory.

A-062

Anonymous

PURE FLUID CONTROL DEVICES AND THE DESIGN OF PRINTED PNEUMATIC CIRCUITS

Automatics and Telemechanics, Vol. XXIV, No. 8, Published by the Academy of
Sciences, USSR, Moscow, August, 1963

A series of devices containing aerodynamic action elements and using printed
circuits have been built at the Institute of Automatics and Telemechanics. For a
considerable time now a continuous action pure fluid regulator has been operating
at an industrial installation under complex operating characteristics. A specialized
aerodynamic digital information machine designed for controlling the receipt and
expenditure of parts under assembly-line production conditions has been built. Other
aerodynamic action devices have also been built including integrating devices,
measuring hoppers for supplying the individual parts which go into a product and
which consider in advance the number of parts which will be required, etc. At the
present time pure fluid control and regulation devices can soon be expected to
receive broad employment in industry.

A-063

Anonymous

SPECIAL REPORT: FLUIDICS

Missile and Rockets, February 8, 1965

Missiles and Rockets predict that the Fluidics Market may hit $250 million
by 1970. Already used in industry for process and other control applications
systems will soon be operational in missiles, subs, ships and aircraft.

A-064

Anonymous

THE CHALLENGE OF FLUID LOGIC

Product Design Engineering, March, 1965, Pages 44 and 45

A-065

Anonymous

THE DOUBLE LEG ELBOW AMPLIFIER

SAE PANEL for standardizing Fluid Amplifier Symbols & Nomenclature, May 15, 1965

The Double Leg Elbow Amplifier differs from most other fluid state devices because it was invented by aerodynamicists. It employs the principles of airfoil aerodynamics, involving relatively low velocity, large cross section fluid streams. In employing these principles, it achieves unusually high flow and power gains with low pressure drop.

A-066

Anonymous

THE FLUID TRIODE

Machine Design, March 17, 1960

Hydraulics may soon take over some jobs now assigned to electronic systems. A new control principle makes practical some fluid-operated devices that are analogous to electron tubes.

Limitations to performance are primarily due to spread of flow through passageways in the control unit. Faster than mechanical systems and slower than electronic fluid-triode circuits will inherit some of the jobs of each. Greatest item, however, will probably be in applications that are not practical for other systems.

A-067

Anonymous

THE PNEUMATIC COMPUTER IS ON THE WAY

Automation Data Proc., Vol. 3, April, 1961, Pages 18-30

A-068

Anonymous

THE PNEUMATIC TYPEWRITER MAKES ITS DEBUT

New Scientist, May 30, 1963, Page 493

A-069

Anonymous

WHERE'S THE PROFIT IN FLUID AMPLIFIERS

Control Engineering, July, 1965, Page 57

Six years, $30 million development efforts by more than 50 companies, and increasing frequently technical meetings--all have resulted in only four suppliers of fluid amplifier components. The four who have offered devices include the Howie Corp., Bowles Engineering Co., Moore Products Co., and Corning Glass Works. Corning has been the largest source of the HDL type amplifiers, with some 15 stock amplifiers and logic elements available in their Fotoceram material. Distribution, marketing and packaging of Corning fluid amplifiers, however have recently been licensed to Imperial-Eastman. Corning will continue to design and manufacture unitized system packages.

A-070

Astromechanics Research Division

FLUID STATE AMPLIFICATION

An Abstract of Reports Issued by THE ASTROMECHANICS RESEARCH DIVISION of GIANNINI CONTROLS CORPORATION

A-071

Auger, Raymond N.   (Fluid Logic Control Systems, Bowles Engrg Corp.)

HOW TO USE TURBULENCE AMPLIFIERS FOR CONTROL LOGIC

Control Engineering, June 1964, Pages 89-93

Turbulence amplifiers are the only pure fluid amplifiers available that a user can apply directly in complex and useful digital logic systems. They are NOR logic devices, and systems require practically no other parts except interconnecting plastic tubing. There are no impedance matching problems. Here are the techniques for using them, plus the logic for a useful programmable counter circuit which has controlled a production assembly machine 10 hours a day, 6 days a week for a year without failure.

A-072

Auger, Raymond W.

PNEUMATIC TURBULENCE AMPLIFIERS

Instruments & Control Systems, March 1965, Vol. 38, Page 130
Also Proceedings of the Fifth National Chemical and Petroleum Instrumentation
Symposium, Wilmington Del, May 4-5, 1964

When a laminar stream is made turbulent, the kinetic (velocity) pressure
is reduced. As the pressure change resulting from a change in stream
characteristic is larger than the pressure required to cause the change,
the device is a "turbulence amplifier". A turbulence amplifier makes use
of the basic pressure difference between a laminar stream and a turbulent
stream of air to provide a binary pressure signal for use in logic and
counting circuits.

A-073

Auger, R. N. (Marquardt Corporation)

THE TURBULENCE AMPLIFIER IN CONTROL SYSTEMS

Proceedings of the HDL Fluid Amplification Second Symposium, Vol. II, May
26-28, 1964, N-64-23821

The turbulence amplifier was first described as a component for fluid
logic systems at the 1962 Symposium on Fluid Amplification. At that time
hundreds of these devices had been built for use in experiments and model
systems. Control circuits using various input techniques, logic functions
and output transducers had been thoroughly tested to verify the practicality
of the turbulence amplifier as a control and switching element. Since
then progress has been made in both improving the design of TAs and
fabrication techniques for manufacturing them and also in applying them to
an increasing number of situations. Extensive experience has now been gained
in their use in industrial environments. It has been established that complex
systems using hundreds of TAs can reliably operate day after day on
conventional shop air, summer and winter, in the presence of severe noise,
vibration and moisture in the air supply and that TA systems can be integrated
with complex machine systems by industrial personnel who are not specialists
in the fluid logic field.

A-074

Avduevskii, V. S.

APPROXIMATION METHOD OF COMPUTING THE THREE-DIMENSIONAL LAMINAR BOUNDARY LAYER

DDC Report AD600 524 (Foreign Tech Air Force Systems Command, USSR Report)
Wright Patterson, March, 1964

In the system of curvilinear orthogonal coordinates connected with the
lines of flow of an ideal fluid on the surface of a body, and disregarding
the secondary currents, a method is used analogous to the method of computing
the axisimetrical boundary layer. There are proposed approximation expressions
for the correction factor conciliating formulas obtained with the results
of the numerical computations of the equations of the three-dimensional
boundary layer on the lines of flow spreading.

A-075

Avery, H. W.; Kantola, R. A.; Ziemba, R.

FLUID TIMER FOR ORDNANCE APPLICATIONS

DDC Report AD600661 (General Electric Company quarterly Report No. 3)
(Contract DA19020AMC 0213A) January 15--April, 1964

This report describes the work carried out to develop a fluid timer
demonstrator. The demonstrator uses fluid amplifiers without moving parts.
Activity was concentrated on perfecting the operation of the counter stages
and investigating new oscillator designs. The 17 stage counter was completed
and final assembly of the demonstration timer package was started.

A-076

Ayre, V. H.; Dunaway, J. C.

A STATUS REPORT ON THE EXPERIMENTAL DEVELOPMENT OF A HOT GAS VALVE

See Author Dunaway, J. C.

A-077

Ayre, V. H.; Lee, P. D.

AN ANALYSIS OF A TWO AXIS FLUID CONTROL SYSTEM FOR AN ARTILLERY TYPE MISSILE

Paper presented at the AIAA/ION Guidance & Control Conference, August 16-18, 1965 at Minneapolis, Minnesota

A-078

Ayre, V. H.; Dunaway, J. C.

DEVELOPMENT OF A HOT GAS BI-STABLE JET REACTION CONTROL VALVE

U. S. Army Missile Command Redstone Arsenal, Alabama, April 13, 1964

There has been a high degree of interest recently in the use of solid and liquid propellant hot gas generators as a primary or secondary source of power for missile control systems. This report describes a low cost hot gas control valve presently under development at the Army Missile Command.

B-046

Babcock & Wilcox Limited and Christopher Davy

METHOD OF AND MEANS FOR CONTROLLING THE FLOW OF A GASEOUS FLUID IN A CONDUIT, DUCT OR THE LIKE

Patent Spec. 444,103, January, 1936

Claims of methods: 1) a method of controlling flow of gaseous fluid through a conduit, duct, or the like, consisting in injecting or projecting across a stream of gaseous fluid flowing therethrough one or more secondary streams of gaseous fluid at higher pressure so as to reduce the effective free area for the flow of the gaseous fluid through the conduit. 2) a method of controlling the flow of gaseous fluid through a conduit, wherein the fluid used for secondary stream is obtained from the primary stream at a point (s) located on the downstream side of the control point.

B-047

Balda, Milan

NEW SYSTEM OF PNEUMATIC LOGICAL CONTROL

DDC Report AD607156 (Foreign Tech. Div. Air Force Systems Command - WPAFB) September, 1964

Unedited rough draft translation of Automatizace (Czechoslovakia) 1962, V5 No. 3 Pages 58-60

B-048

Banta, E. D.

LOSSLESS PROPAGATION OF ONE-DIMENSIONAL, FINITE AMPLITUDE SOUND WAVES

Journal of Mathematical Analysis and Applications, Vol. 10, Pages 166-173 (1965)

Recent publications show a revived interest in the study of finite amplitude sound waves. This likely due to the greater availability of electronic computers for evaluating iterative procedures and to a general broadening of knowledge about nonlinear equations and their solutions. This paper derives the nonlinear partial differential equation of propagation without recourse to the theory of characteristics for an arbitrary isentropic state equation. Its solution is given in a new form involving only a function prescribed along one boundary.

B-049

Bauer, P. (Sperry-Rand)

"AND" GATE

U. S. Patent No. 3,191,611 dated June 29, 1965, filed January 25, 1963

This invention relates to fluid-operated devices for performing the logical AND function. More particularly this invention provides a plurality of series-connected fluid amplifiers and a plurality of sources of fluid signals, the sources being selectively and independently operable to apply fluid control signals to the amplifiers whereby an output signal is produced in one output channel of the last amplifier in the series only, when the sources apply control signals to all of the amplifiers concurrently.

B-050

Bauer, P. (Sperry-Rand)

BINARY COUNTER

U. S. Patent No. 3,182,676 dated May 11, 1965, filed April 23, 1962

This invention relates to binary counter stages operating on pure fluid principles. More particularly it relates to binary counter stages of the type having two bistable pure fluid amplifiers interconnected such that each pulse received by a first amplifier causes the second amplifier to change from one stable state to the other.

B-051

Bauer, P. (Sperry-Rand)

BINARY COUNTER STAGES HAVING TWO FLUID VORTEX AMPLIFIERS

U. S. Patent No. 3,193,197 dated July 6, 1965, filed April 23, 1962

This invention relates to bistable devices of the type suitable for use as binary counters. More particularly provides pure fluid devices of the bistable type which switch from one stable state to the other in response to each pulse received at a single input.

B-052

Bauer, Peter & Metzger, Eric E.

DIGITAL DATA HANDLING SPEEDS WITH PURE FLUID (PNEUMATIC) CIRCUITS

Proceedings of the HDL Fluid Amplification Symposium - Vol. II, October, 1965

Digital Data Handling is defined as the manipulation of numerical data in the form of discrete level signals, in this case, Pure Fluid signals. On the basis of this definition, present and future capabilities are construed, with the help of theoretical considerations supported by test results. Extreme boundaries are placed upon speed capabilities by considerations of logic requirements on one hand, and projected Pure Fluid element performance capabilities on the other hand.

Expectations and means of practically feasible future speed improvements are discussed, such as element and circuit design, miniaturization and power levels, pneumatic media, and logic circuit methods, with respect to the outlined boundaries. Numerical data handling applications suited to Pure Fluid circuit speed capabilities are mentioned.

B-053

Bauer, P. (Sperry-Rand)

FLUID MULTI-STABLE DEVICE

U.S. Patent No. 3,192,938, dated July 6, 1965, filed September 5, 1961

This invention relates to a multistable fluid operated device which utilizes the flow of a fluid such that the device performs functions which are analogous to some functions now being performed by electronic components or other electrical devices, such as a switch.

B-054

Bauer, P. (Sperry-Rand)

FLUID SIGNAL GENERATOR

U.S. Patent No. 3,204,652 dated September 7, 1965, filed December 28, 1961

It is the object of this invention to provide an improved generator operating on fluid principles to provide fluid pulses.

B-055

Bauer, P.; Sowers, E. U. III (Sperry-Rand)

FLUID SORTER

U.S. Patent No. 3,169,639 dated February 16, 1965, filed August 19, 1965

This invention relates to means for sorting record cards or the like, and more particularly to means having fluid as the operative sensing and sorting medium so as to avoid the need for any moving mechanical parts.

B-056

Bauer, P.

PNEUMATIC TIMER FEASIBILITY STUDY FOR ARTILLERY FUZE APPLICATION

DDC, Bowles Engineering Corp., AD450413, Contract AF33(657)10705, October 16, 1964

The object of this study is the determination of the feasibility of applying the concepts of pneumatic timing to meet the requirements demanded of artillery fuzing including the establishing of the advantages and limitations of proposed pneumatic systems attempting to conform to typical artillery fuze specifications and the finding of indications of possible solutions to the various problems which may arise.

The resulting fuze (after studies and experiments) timer concept is a timer, settable in 0.1 second increments up to 180 seconds (accuracy 0.2 second dispersion), capable of packaging within a conventional artillery fuze contour, withstanding standard military tests and capable of operating under conventional artillery projectile environmental conditions.

B-057

Bell, R. W. (British Telecommunications Research Limited, Plessey Electronics Group, U.K.)

AN APPLICATION OF FLUID LOGIC TO TELEGRAPHY AS A RESEARCH VEHICLE.

Paper given at the First Conference on Fluid Logic and Amplification sponsored by the British Hydromechanics Research Association and college of Aeron. Cranfield, England, September 9-10, 1965.

B-058

Belstering, C. A. (Giannini Controls Corp.)

A FLUID STATE ABSOLUTE PRESSURE RATIO COMPUTER

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. III, October, 1965

This paper describes a pneumatic Absolute Pressure Ratio Computer with no moving parts (fluid state). It covers the concept and design of the components and circuits and includes an evaluation of the resulting demonstration system. The performance of the breadboard Fluid State Ratio Computer firmly establishes the feasibility of the concept. It demonstrates that sophisticated analog computing components can be developed to operate on fluid-state variables. It also illustrates that complex fluid state components can be interconnected into a useful system by means of straight-forward analytical techniques.

B-059

Belstering, C. A. and Tsui, Ka-Cheung (Franklin Institute)

ANALYZING PROPORTIONAL FLUID AMPLIFIER CIRCUITS

Control Engineering Page 87, August 1965,

Control engineers anxious to apply fluid amplifiers have been severely handicapped by a lack of suitable analytical techniques and an adequate description of amplifier behavior. This article presents graphical characteristics, equivalent electric circuits, transfer functions, and a method for predicting static and dynamic performance in a practical system. The approach is generally applicable to all types of fluid devices and has been verified by experiment for the jet deflection type of amplifier.

B-060

Belsterling, C. A.; Tsui, K. C. (Franklin Institute, Philladelphia)

APPLICATION TECHNIQUES FOR PROPORTIONAL PURE FLUID AMPLIFIERS

Proceedings of the HDL Fluid Amplification Symposium, Vol. II, May 26-28, 1964
N-64-23817

This paper describes a program of experimental and analytical research on pure fluid amplifiers currently being conducted at the Franklin Institute.
The ultimate objective of this research program is to promote the application of pure fluid devices in systems, by describing those devices in terms familiar to the control systems engineer.

B-061

Bendix Corporation

BENDIX RESEARCH LABORATORIES ACTIVITIES IN ALL FLUID-TECHNOLOGY

The activities at Bendix Research Laboratories in all-fluid technology have been, to a large extent, Corporation supported. Consequently, the results which have been achieved and the methods employed are, in most cases, of a proprietary nature. In addition, a portion of the work is classified.

The all-fluid efforts at Bendix Research Laboratories include both research in basic fluid dynamic phenomena and the application of those phenomena to control elements, sensors, and subsystems.

Research and development efforts have been centered principally around vortex, jet, and boundary layer phenomena, and the application of those phenomena to rate, temperature, pressure, and other proprietary sensors; amplifiers, control valves, and digital logic elements; and control systems for gas turbine engines, nuclear reactors, space power systems, and flight vehicles.

B-062

Benedict, E. B.

FLUID AMPLIFIER INSTRUMENTATION

Paper - Martin Company, Orlando, Florida

Some techniques for fluid flow data investigated include turbines, positive displacement devices, total pressure probes (pitot tubes), devices for magnetohydrodynamic flow measurements, and hot-wire anemometers. The pressure measurements of various locations throughout the working area of the fluid amplifier are also discussed.

B-063

Bermel, T. W.; Brown, W. R. (Corning Glass)

DEVELOPMENT OF A PURE FLUID NORGATE AND A NORLOGIC BINARY TO DECIMAL CONVERTER

Proceedings of the HDL 3rd Fluid Amplification Symposium, October, 1965 Vol. III, (also) ASME Paper 65 WA/AUT - 13 presented at the Winter Annual Meeting- Chicago, Illinois, November 7-11, 1965

A review of the empirical approach to the design and fabrication of an active, two-input, pure fluid OR-NOR Gate is presented. Performance criteria and testing methods for this device are discussed relative to a discrete standard breadboard-type component.

B-064

Bertin, Jean; Maunoury, François; Kadosch, Marcel

FLUID FLOW CONTROL DEVICE FOR JET PROPULSION NOZZLES

    See Maunoury, François

B-065

Bertin, J.; Kadosch, Marcel (translated by Dr. J. G. Moorhead)

PRINCIPLES AND APPLICATIONS OF AXIAL AND DIRECTIONAL CONSTRICTION

Bulletin - The Société François Des Méconiciéns, 1958

    The principle of control of a jet in direction, flow and impulse,
particularly by the action of auxiliary transverse jets, performance with very
low time constants and development of lightweight devices. Description of
the principal devices built.

B-066

Besant, R. W. and Srinivas, V.

FLUID DYNAMIC EFFECTS OF LIQUIDS IN ELASTIC TUBES

Proceedings of the HDL Fluid Amplification Symposium - Vol. II, October, 1965

    In this paper a theoretical analysis is made of the frequency response
of liquid flow in an elastic line for a load at one end and an input
oscillator at the other end. Interaction, transverse and longitudinal wave
modes are analyzed for the system by linearizing the general partial
differential equations of motion for the liquid and the elastic tube and by
superimposing second order effects on the first order equations. The results
yield different superimposed resonant frequencies for each wave mode and they
should be valid within the bounds of the assumptions made.

B-067

Betchov, Robert

GENERAL RESEARCH ON THE CURVATURE AND TORSION OF AN ISOLATED VORTEX FILAMENT

DDC Report AD-600459 (Aerospace Corp. Report on Contract ATN6492314), May, 1964

The paper deals with the motion of a curved and isolated vortex filament immersed in an infinite, incompressible, and inviscous fluid. The filament is not necessarily plane; attention is focused on its curvature and its torsion. These quantities vary with the position along the filament and with the time.

B-068

Betchov, R.

THERMAL AGITATION AND TURBULENCE

IAA - A63-11324 (International Symposium on Rarefied Gas Dynamics 2nd Proceedings, Berkeley, California, August, 1960

Investigation of the nature and the possible effects of thermal agitation in ordinary fluids and in plasmas. The spectra of the velocity fluctuations and of the magnetic field fluctuations are obtained under the assumption of incompressibility. The amplification of thermal fluctuations in shear flows is studied by referring to the theory of hydradynamic stability. The results suggest that amplified thermal agitation may cause turbulent transition in many common situations. The amplification of thermal fluctuations may also be important in a fully developed turbulent flow.

B-069

Bidgood, R. E. and Charnley, C. J.

FLUID UNITS OF THE BALL VALVE TYPE AND THEIR APPLICATION TO THE CONTROL OF A MACHINE TOOL

Cranfield Department of Production and Industrial Administration

The paper begins with a review of experimental work done at Cranfield into the characteristics and behavior of ball valve switching devices and indicates the scope of the present investigations which are being sponsored by the Department of Scientific and Industrial Research.

Part II of the paper deals with the design and fabrication of a fluid logic control system for application to a step controlled grinding machine which is used for research at the College.

B-070

Bidgood, R. E.; Charnley, C. J.

THE DESIGN OF A PNEUMATIC LOPE RECORDER

   See Charnley, C. J.

B-071

Bidgood, R. E.; Boardman, G.E.T.; Charnley, C. J.

THE DESIGN OF A PNEUMATIC POSITION ENCODER

   See Charnley, C. J.

B-072

Biot, M. A.; v Kármán, T.

MATHEMATICAL METHODS IN ENGINEERING

McGraw-Hill Book Company, Inc. 1940

B-073

Bisshopp, F. E.

INTERNAL ANGULAR MOMENTUM AND INTERNAL ENERGY OF FLUIDS

DDC Report AD-612086 (Brown University; Prov. R. I. Report for contract
NONR562 07), January, 1965

  A refinement of the usual equations of fluid dynamics applicable to
fluids whose internal rotational degrees of freedom provide observable effects
is here developed. The formulation proceeds along the lines of classical
continuum mechanics and thermodynamics.

B-074

Bjornsen, Bjorn G. (Johnson Service Co.)

A FLUID-AMPLIFIER PNEUMATIC CONTROLLER

Control Engineering, June, 1965, Page 88

Control makers continuously seek to serve the multifaceted needs of process control users. This is particularly true in Controllers. The needs range from improved control to lower cost. Attempts include introduction of electronic controllers and trials of direct digital control. Another reasonable approach appears to be the improvement and reduction in cost of prosaic equipment. Along this line comes a low-cost pneumatic controller that takes advantage of the much-heralded but little-used fluid amplifier technology. Now proportional-only, it can easily be designed into a three-mode controller.

B-075

Bjornsen, Bjor G. (Johnson Service Co.)

THE IMPACT MODULATOR

Proceedings of the HDL Fluid Amplification Symposium Vol. II, May, 1964

The paper explains how the familiar mechanical motion-balance concept has been applied to the design of a new basic pure fluid component called the Impact Modulator. Two design versions called the Transverse Impact Modulator and the Direct Impact Modulator are discussed in regard to pressure and flow gains.

The output signals can be above and/or below standard atmosphere, i.e. positive and/or negative output flows and pressures are possible.

The DIM incorporates a unique input signal method which not only can accept positive and/or negative signals in the above sense, but also has a very high input impedance, approaching infinity, which increases its sensitivity and reduces several loading problems as exemplified by the cascading of two DIM yielding a pressure gain of approximately 8000:1 and a starting input pressure of 0.00125 psig.

B-076

Blackburn, John F.; Riethof, Gerhard; Shearer, J. L.

FLUID POWER CONTROL

Technology Press of MIT and John Wiley and Sons, Inc. - New York, 1960

B-077

Blanchard, D. L.; Sewell, Clinton

PURE FLUID TECHNOLOGY AND POSSIBLE ORDNANCE APPLICATIONS

DDC Report AD-612503 (Naval Ordnance Lab Report, NOLTR-64-115), December, 1964

    Pure Fluid i.e. no moving parts, Technology is a new and rapidly expanding field which shows much promise for many applications where it is desirable to have a rugged and dependable logic system. The primary purpose of the report is to combine much of the basic knowledge of the state-of-the-art of pure fluids and to investigate ordnance applications.

    The report explains the basic operation of the bi-stable amplifier, analogue amplifier, OR/NOR element, flip-flop, binary counter, and simple oscillator. It further discusses some sensors which are either pure fluid or give a fluid signal. Proposed pure fluid circuits for free fall, tactical missile and ballistic missile applications are included. Free fall and tactical missile laboratory breadboard pure fluid circuits were successfully demonstrated.

B-078

Blunck, George C and Schuder, Charles B.

THE DRIVING POINT IMPEDANCE OF FLUID PROCESS LINES

ISA Transactions, Vol. 2, No. 1, 1963, pages 39-45

    Transfer functions for the driving point impedance and input-output response of fluid process lines are presented. It is shown that the driving point impedance of many process lines can be adequately described at all frequencies by two relatively simple functions. Relationships are developed to facilitate the application of the functions to a variety of operating conditions and system configurations. Experimental results obtained from tests on 1-in. air lines showed good agreement with theory.

B-079

Boardman, G.E.T.; Bidgood, R.E.; Charnley, C. J.

THE DESIGN OF A PNEUMATIC POSITION ENCODER

See Author Charnley, C. J.

B-080

Bodine, A. G.

OSCILLATORY FLUID STREAM DRIVEN SONIC GENERATOR WITH ELASTIC AUTORESONATOR

U. S. Patent No. 3,111,931 dated November 26, 1963, filed March 31, 1960

This invention relates generally to resonant acoustic generators useful as sound sources in many applications of sonic processing such as accelerating chemical reactions, sonic cleaning, actuation of sonic drills, etc. The invention is more particularly concerned with a novel sonic generator involving a type of fluid stream oscillator having a fluid stream either liquid or gas, periodically deflected between two flow paths under control of an elastic resonator.

B-081

Boksenbom, A. S.; Laverne, M. E.

FREQUENCY RESPONSE OF LINEAR SYSTEMS FROM TRANSIENT DATA

NACA Report 977   -   1950

B-082

Boothe, Willis A. (General Electric Company)

A LUMPED PARAMETER TECHNIQUE FOR PREDICTING ANALOG FLUID AMPLIFIER DYNAMICS

Preprint of paper given at Joint Automatic Control Conference at Stanford University, June 24-26, 1964

Fluid Amplifier devices with no moving parts offer considerable promise as simple, reliable elements for control systems. One of their advantages is a high speed of response compared to conventional pneumatic and hydraulic controls. This paper is concerned with a simplified method for predicting the response of the analog (or proportional) form of fluid amplifier.

B-083

Boothe, W. A.; Shinn, J. N.   (G.E. Co.)

CONNECTING ELEMENTS INTO CIRCUITS AND SYSTEMS

Discussion of methods for interconnecting fluid amplifiers in control circuits and systems. Input and output characteristics of, and impedance-matching techniques for, pure fluid devices are considered. Methods for building digital circuits, and for staging analog circuits, including carrier-type systems, are discussed. Practical circuit-fabrication procedures are described.

B-084

Boothe, W. A. (G. E. Co.)

FEASIBILITY STUDY--APPLICATION OF FLUID AMPLIFIERS TO REACTOR ROD CONTROL

This study shows that it is feasible to use fluid amplifiers to replace the electronic portions of electropneumatic drives for reactor rod control systems under development. The fluid amplifiers and associated circuit elements are reasonable in size and gas consumption. Several methods of controlling power flow to the actuator were considered, including one vortex valve circuit with no moving parts. Indications are that this will have low efficiency. A simplified version of the present single stage electropneumatic valve is recommended for adaption to fluid amplifier operation.

B-085

Boothe, W. A. (G. E. Co.)

FLUID AMPLIFIER

This invention relates to a fluid amplifier of the jet valve type which employs no moving parts, and in particular to a variable gain fluid amplifier that utilizes an additional control jet and plurality of receivers to obtain the gain changing feature. The principal object of this invention is to develop a new and improved variable gain fluid amplifier.

Boothe, W. A. (G. E. Co.)

FLUID CONTROL DEVICES

U.S. Patent No. 3,181,546 dated May 4, 1965, filed November 8, 1962

It is an object of this invention to provide a fluid control device having novel and improved means for effecting a high pressure recovery of the power jet. It is another object to provide a fluid control device having a novel and improved venting arrangement for venting excess fluid from the device without impairing pressure recovery.

B-087

Boothe, W. A.; Ringwall, C. G.; Shinn, J. N. (G. E. Co.)

NEW FLUID AMPLIFIER TECHNIQUES FOR SPEED CONTROLS

SAE 1965 Aerospace Fluid Power Systems & Equipment Conference, Proceedings Los Angeles, California, May 18-20, 1965, Pages 275-281

Fluid amplifiers are now receiving considerable attention by control engineers due to their potential for high reliability, ruggedness, and fast response. For applications such as speed controls for jet engines, steam turbines and other prime movers, fluid amplifier systems are now being studied that use both digital and analog techniques. This paper describes several approaches to shaft speed control that differ from the above techniques in that fluid circuits analogous to A. C. carrier systems are used. Results of testing are presented for three specific "A-C" fluid amplifier circuits.

B-088

Boothe, W. A. (G. E. Co.)

PURE FLUID LOGIC CIRCUITRY FOR INTEGRATORS AND DIFFERENTIATORS

U. S. Patent No. 3,155,825 dated November 3, 1964, filed February 21, 1963

This invention relates to analog type fluid amplifer circuits and in particular to fluid amplifier circuits that perform mathematical integration and differentiation computation.

B-089

Boucher, R. F.; Markland, E. (University of Nottingham, U.K.)

EXPERIMENTS ON SYMMETRICAL WALL RE-ATTACHMENT AMPLIFIERS

Paper given at the First Conference on Fluid Logic and Amplification, September 9-10, 1965, sponsored by the British Hydromechanics Research Association and College of Aeron. Cranfield, England.

B-090

Boucher, R. F.; Markland, E; Oels, R. A.

EXPERIMENTS ON TURBULENCE AMPLIFIERS

See Author Oels, R. A.

B-091

Bowles, Dr. R. E. (Bowles Engineering Corp.)

ANALOG PURE FLUID SYSTEMS

American Helicopter Society Journal, Vol. 10, January, 1965, Pages 35-42.

In general, it may be stated that Pure Fluid Controls can provide any function desired that can be provided with electrical circuitry. The Pure Fluid System is limited in response speed by signal transmission speed of the order of the speed of sound whereas electronics is limited by the speed of light. In general, internal control systems do not need or make use of the transmission speed available from electronics. The low cost and high reliability, ruggedness and tolerance of extreme environment offered by Pure Fluid Systems insure their contribution to the helicopter and VTOL aircraft controls fluid.

B-092

Bowles, R. E. Dr.

A PURE FLUID HYDROFOIL CONTROL SYSTEM

There is at present a rapidly growing interest in Hydrofoil Boats.
There has existed a gap in the modes of transportation over bodies of water.
Transportation by the conventional type of ship is relatively inexpensive but
slow. If time is of sufficient importance, flying, though much more expensive,
becomes justifiable. The hydrofoil appears to fit into the space between these
two means.

The hydrofoil craft "flies" on foils, in many cases similar to airfoils.
At cruising speeds the hull is lifted out of the water, with only the foils
and supporting struts contributing drag forces. The speed barrier encountered
in conventional craft due to hull friction forces and energy losses in large
gravity waves is thus overcome.

B-093

Bowles, R. E., Dr; Dexter, E. M. (Bowles Engineering Co.)

A SECOND GENERATION OF FLUID SYSTEM APPLICATIONS

During the past three years, Pure Fluid Systems have progressed to the
fabrication of integrated controls and some operational experience has been
accumulated. These controls are more than breadboard samples; they have been
built for specific applications. The manner of their execution is the result
of an evolution. The first step in this evolution was to select applications
which, on the surface at least, were compatible with Fluid Systems. Secondly,
we would like to believe that the evolution represents a collective best judgment
at each step. Each development approach is the result of a consideration of the
best way.

The objective of this paper is to review some applications which represent
the average or mean rather than the extremes (what is being done rather than
what might be done) in an attempt to define the future complexion of Fluid
Systems. We have selected five of these middle-of-the-road applications.
We think they cover a fair sampling of present day work and, therefore,
are suitable to deduce some general characteristics of the applications of
Fluid Systems. These five selections are: 1) a boiler control system; 2)
a speed control; 3) a pressure discriminator for process control; 4) a course
control for a torpedo; and 5) an automatic sequencing control system. For
each of these we will describe the basic function of the control and point out
some of the salient features of the end item hardware.

B-094

Bowles, R. E. (Dr.)

FLUID AMPLIFIERS, DESIGN, THEORY, AND FUNDAMENTALS FOR CONTROL SYSTEMS

Paper presented at a meeting of the Society of Automotive Engineers on
October 3, 1963 at Kansas City

    A short discussion of the objectives of a fluid control system is made
and information to provide a sketch as to how they apply these fundamentals to
the design of a specific pure fluid control system. As an example, a discussion
is made on the servoed-hydrofoil which they have been working on at the Bowles
Engineering Corporation under sponsorship of the Navy, Bureau of Ships.

B-095

Bowles, R. E. (Dr.)

FLUID CONTROL SYSTEMS FOR FOILS

U. S. Patent No. 3,209,714 dated October 5,1965, filed October 14, 1963

    This invention relates to a fluid operated servocontrol system for controlling
the lift of a foil supporting an air or water craft during movement of the craft
in the fluid medium

B-096

Bowles, R. E. (Dr.); Horton, B. M.

FLUID OSCILLATOR

U. S. Patent No. 3,185,166 dated May 25, 1965, filed April 8, 1960

    See Author Horton, B. M.

B-097

Bowles, R. E. (Dr.) (Bowles Engineering Co.)

PASSIVE PURE FLUID COMPONENT

U. S. Patent No. 3,191,623 dated June 29, 1965, filed February 21, 1963

    This invention relates to fluid operated systems and particularly to circuit
elements therein such as diodes, time delay means and pressure dividers.

B-098

Bowles, R. E.; Warren R. W.

PERFECTIONNEMENT AUX SYSTEMES ACTIONNES PAR UN FLUIDE

French Patent No. 1,278,782 dated November 23, 1960

B-099

Bowles, R. E.; Warren R. W.

THREE DIMINSIONAL JET VECTORING SYSTEM

U. S. Patent No. 3,204,405 dated September 7, 1965, filed February 20, 1964

    See Author, Warren, R. W.

B-100

Bowles, R. E.

VACUUM CLEANER

U. S. Patent 3,075,227, January 29, 1963

    The present invention relates generally to fluid operated devices, and
more particularly to devices for generating and controlling fluid vortices
and for applying the vortices so generated and controlled generally to the art
of cleaning by inducing fluid flow over the article to be cleaned, and more
particularly to the air flow cleaning of floors, fabrics, rugs and the like,
or to water-flow cleaning of underwater surfaces, such as the bottoms or
walls of swimming pools, or the like.

B-101

Bowlin, R. C.; Rose R. K. (G. E. Co.)

DYNAMIC INTERACTION ANALYSIS AND COMPUTER MODEL LEM REACTION CONTROL PROPULSION
SYSTEM.

Vol. 1 Technical Discussion

Grumman Aircraft Engineering Corp., Final Report prepared by the General Electric
Company March, 1965

B-102

Bradshaw, P. and Gee, M. T.

TURBULENT WALL JETS WITH AND WITHOUT AN EXTERNAL STREAM

Reports and Memoranda No. 3252*, June, 1960

The results are presented of experiments on wall jets in still air on flat and curved surfaces, and beneath an external stream in presence and absence of pressure gradient and initial boundary layer. It is found that the Reynolds shear stress is not zero at the velocity extreme, invalidating the simple assumptions of layer independence made by other workers: it is concluded that a satisfactory calculation method is not immediately practicable. The behavior of wall jets is discussed in some detail on the basis of the experimental results.

*Previously issued as A.R.C. 22,008.

B-103

Brady, W. Gordon and Ludwig, Gary

THEORETICAL AND EXPERIMENTAL STUDIES OF IMPINGING UNIFORM JETS

Presented at the IAS 31st Annual Meeting, New York, N. Y., January 21-23, 1963
IAS Paper No. 63-29

The flow field under a uniform circular jet perpendicular to and impinging on the ground was studied experimentally and theoretically in order to further the understanding of the aerodynamic processes associated with ground particle entrainment in the impinging downwash from VTOL aircraft.

Experimental data have been obtained for the flow in the deflected jet and in the ground boundary layer for jet height-to-nozzle diameter ratios (H/D) from 0.25 to 4 for two mass flows. The boundary layer measurements were obtained at radial stations between one-half and four nozzle diameters from the stagnation point.

The flow field of an inviscid uniform jet perpendicular to the ground was analyzed theoretically, based on a vortex sheet model, and partial results obtained. Boundary layer analyses were performed for the laminar region which occurs up to approximately one jet diameter from the stagnation point and for the region beyond two jet diameters from the stagnation point where the flow is of the wall-jet type. These two regions were joined by means of a semiempirical analysis based on an assumption as to loss in momentum flux in the transition zone joining the laminar boundary layer and wall-jet flow. Comparisons between the results of the theoretical analyses and the experimental results are made.

B-104

Brown, C. C.; Vince, J. R. (British Aircraft Corp. U. K.)

THE APPLICATION OF FLUID JET DEVICES TO A MEDICAL RESPIRATOR

Paper given at the First Conference on Fluid Logic and Amplification, September 9-10, 1965, sponsored by the British Hydromechanics & Research Association and the college of Aeron. Cranfield, England.

B-105

Brown, D.

FLUID AMPLIFICATION

Metal Working News, January 11, 1965

B-106

Brown, F. T. Editor (Massachusetts Institute of Technology)

FLUID JET CONTROL DEVICES

American Society of Mechanical Engineers, Hydraulic and Automatic Control Division, Winter Annual Meeting and Symposium on Fluid Jet Control Devices, A63-13665, November 28, 1962

This collection of papers and discussions constitute the first publication of detailed technical information by a professional society in the new field of fluid-jet modulators or control devices involving no moving mechanical parts.

Continuous and bistable amplifiers are discussed almost to the complete exclusion of logic elements, reflecting on the highly proprietary interests of a new field as well as the state of the art. Vortex amplifiers also are not discussed, partly because their unique load-impedance properties have not been widely appreciated.

B-107

Brown, F. T.

FLUID JET MODULATORS AND SYSTEMS

Fluid systems with no moving mechanical parts have received considerable attention in the past four years. Most of the components of these systems could be called "fluid jet modulators," because they involve controlled distrubances of fluid jets. Amplifiers, bistable relays, logic elements, oscillators, and diodes are the most common devices.

The absence of moving parts gives these devices an advantage over other mechanical valves in speed of response, cost, life, and operation in extreme environments. They usually have the disadvantage of a "power jet" which constantly drains valuable energy, as in open-centered mechanical valves. Moreover, the efficiencies are apt to be lower, and at present noise and instabilities raise occasional havoc. Hopefully these faults will be considerably improved as the present meager understanding of the phenomena is increased.

B-108

Brown, Forbes T.

ON THE FUTURE OF DYNAMIC ANALYSIS OF FLUID SYSTEMS

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965

Analyses of fluid amplifier systems at frequencies for which the basic amplification regions themselves exhibit significant dynamic effects have scarcely been done. The possibility of effective future analysis is discussed. Prime-element conceptual models of the components and systems are concluded to be the best approach, from the viewpoints of information content, intuitive feel, and ease of computation. Lumped, mixed lumped-distributed, and pure distributed models are compared, with emphasis on the last. Particular dynamic effects in jet amplifiers are discussed.

B-109

Brown, F. T.

ON THE STABILITY OF FLUID SYSTEMS

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-28, 1964

Fluid systems, especially those containing proportional fluid amplifiers with no moving parts, often display little-understood bistable or cyclic instabilities. Two general criteria for small-disturbance stability are presented, with simple illustrations involving amplifiers, lines, and volumes. Application of the criteria to real systems is based on separate measurements of certain static and dynamic properties of the more complicated elements, and analysis of the separate properties of the other elements.

B-110

Brown, Forbes T.; Simson, Anton K.

RESEARCH IN PRESSURE-CONTROLLED FLUID JET AMPLIFIERS

M.I.T. for U. S. Army Missile Command, Redstone Arsenal, Alabama, November, 1963

A subsonic pressure controlled, fluid jet amplifier is analyzed to determine the important design parameters. Once these parameters are known, they are considered in terms of stability, linearity, and gain, to determine the optimum design configurations. Water table experiments and observations are used to help determine the proper analytical models. Air models were also used to verify results.

The analysis starts with a consideration of the submerged jet representation. This leads to the addition of control ports, and ultimately to the control flow associated with various control port positions. A simplified form of the general results is plotted for use in linear amplifier design. The control pressure-jet curvature relationship is also considered, as are the effects of upstream resistances in the control lines.

The stability of the control region is investigated. The non-linearities associated with various control port designs are examined, and broad design limits established. An optimum control port shape is given.

The receiver characteristics are obtained as a function of their inlet geometry. Optimum dimensions are found to maximize gain and linearity. Over-all optimum gain functions are presented along with an efficiency plot. Optimum flow pressure, and power designs are calculated. Instabilities resulting from cross-coupling between the receiver ports are predicted and observed. Experimental water table and air results are presented.

B. 111

Brown, F. T.; Nelson, S. E.

STEP RESPONSE OF LIQUID LINES WITH FREQUENCY--DEPENDENT EFFECTS OF VISCOSITY

ASME Paper 64-WA/FE-6, December 3, 1964

Universal step-response plots are given from theoretical considerations for rigid cylindrical lines containing a compressible Newtonian laminar flow liquid. The pressure and flow step inputs and pressure and flow outputs for semi-infinite lines can, with the principle of superposition, be used to estimate the responses of a network of lines, terminations, and so on, for any transient input. Where possible analytic expressions were found for these step responses, but in a certain region of each curve complex numerical routines based on the analytic frequency response were necessary. Analytical expressions are based on propagation and characteristic impedance operators published earlier by one of the authors.

B-112

Brown, W. R.; Bermel, L. W.

DEVELOPMENT OF A PURE FLUID NORGATE AND A NORLOGIC BINARY TO DECIMAL CONVERTER

See Bermel, L. W.

B-113

Brown, W. R. and Van Tilburg, R. W. (Corning Glass)

FLUID AMPLIFIER

Design Engineering, May, 1965, Page 106

Photosensitive glass permits fast and economical fabrication of accurate fluid circuits. Heat transforms material into glass--ceramic with resistance to service environments. Four basic steps in making a fluid amplifier are 1) Light is passed through a negative of the amplifier design onto a sensitized glass plate. 2) The plate is then given a thermal treatment which develops the image of the design in the photosensitive glass. 3) The exposed portion of the glass is then etched to produce the required dimensions. 4) Several fluid amplifier elements are then placed together and sealed with cover plates. The complete assembly is given a heat treatment which transforms the glass into a glass-ceramic.

B-114

Burton, G. T. Jr.; Farron, J. R.; Niehaus, D. J. (Bendix)

FLUID-STATE CONTROL SYSTEMS FOR AEROSPACE NUCLEAR PROPULSION APPLICATIONS

Institute of Aeronautics and Astronautics, Propulsion Joint Specialist
Conference, Colorado Springs, June 14-18, 1965. Paper 65-618 1AA-No. A65-26578

Consideration of the use of fluid-state control systems for aerospace
nuclear propulsion. Fluid-state control subsystems for nuclear propulsion
applications are said to offer the potential of upgrading the reliability of
of the entire system because fluid-state devices have no moving parts and a
number of types have demonstrated capability for operating in severe environmental
conditions. Also, by the fluid-state approach, the attaining of a realistic
reliability goal may be demonstrated simply and inexpensively when compared with
present control techniques. A summary of typical requirements and syntheses of
selected fluid-state aerospace nuclear-electric-propulsion-control-system
functions are presented to illustrate the application of this new and powerful
technology. In addition to examples of fluid-state computing and actuating
methods, concepts are presented for fluid-state sensors and instrumentation.
The steps required to provide fluid-state nuclear-propulsion control systems
for preflight testing by the 1968-1970 period, are listed.

B-115

Byrd, J. L., Clayton, B. J. and Williams, J. G.

DEVELOPMENT OF PURE FLUID MISSILE CONTROL SYSTEM (SUMMARY REPORT FY 62)

U. S. Army Missile Command Report No. RG-TR-62-7, 28 October 1963

This report is an attempt to present the basic fundamentals of some pure
fluid components developed to date so that an insight may be gained for a
complete understanding of pure fluid control systems. The concept of fluid
amplification was developed by Mr. Horton of DOFL less than four years ago.
Military and industrial leaders were quick to recognize and take advantage
of the potential of this new technique and considerable advances have been
made in the field during the last few years.

B-116

Byrd, J. L.; Wetheral, T. G.

DEVELOPMENT OF A PURE-FLUID MISSILE CONTROL SYSTEM

U.S. Army Missile Command Report No. RG-TR-64-18, December, 1964

See Author Wetheral, T. G.

B-117

Byrd, Joe L. and Griffith, William A.

SYSTEM AND COMPONENT CONSIDERATIONS FOR AN ALL PNEUMATIC MISSILE ATTITUDE
CONTROL SYSTEM

Complete guidance and control systems will be developed as a logical
consequence of the rate damper system. A two axis directional control system
is shown in Figure 11. Two axis rate sensors are being developed and further
component development can be expected, expecially in the areas of gain, repeat-
ability and increased efficiency. Acceleration, velocity and displacement
control will be possible.

C-027

Cain, John; Contractor, D. N.

A NOTE ON THE DESIGN OF FLEXIBLE-WALL, VOLUME RESONATOR ACOUSTIC FILTERS

See Contractor, D. N.

C-028

Camarata, J. F.; Olson, R. E.

PRESSURE RECOVERY CHARACTERISTICS OF COMPRESSIBLE TWO-DIMENSIONAL FREE JET FLOWS

See Author Olson, R. E.

C-029

Campagnuolo, C. J.; Sieracki, L. M. (Harry Diamond Labs)

A DIGITAL-PROPORTIONAL FLUID AMPLIFIER FOR A MISSILE CONTROL SYSTEM

Proceedings of the HDL 3rd Fluid Amplification Symposium, October, 1965, Vol. III

This paper deals with the use of fluid amplification for amplifying small control signals emitted from a pneumatic gyroscope. A proportional flow gain of about 500 is achieved. The system produces a proportional output even though its components are digital in nature. It can be used in conjunction with pneumatic gyroscopes to control the pitch, yaw or roll of a missile. Within the atmosphere, the supply to the system can be rammed from the surrounding atmosphere.

C-030

Campagnuolo, C. J.; Foxwell, J. E.; Holmes, A. B; Sieracki, L. M. (Harry Diamond Lab)

APPLICATION OF FLUERICS TO MISSILE ATTITUDE CONTROL

Proceedings of the HDL 3rd Fluid Amplification Symposium, October, 1965, Vol. III

This report describes the design, development, and evaluation of a control and thrust generating system consisting of an RC oscillator, a three-stage amplifier, and a supersonic single-stage power amplifier. These amplifiers were combined into a single four-stage fluid amplifier. The three-stage subsystem provides a modulated oscillatory control signal that enables the digital supersonic amplifier to deliver a proportional thrust output. The overall system has a power gain of 1×10^6 and a flow gain of 1.3×10^4 and delivers a maximum thrust of 70 pounds.

C-031

Campagnuolo, C. J.; Kirshner, J. M.

A TEMPERATURE INSENSITIVE PNEUMATIC OSCILLATOR AND A PRESSURE-CONTROLLED PNEUMATIC OSCILLATOR

See Author Kirshner, J. M.

C-032

Campagnuolo, Carl, J.; Spyropoulos, Chris

A TWO-STAGE DIGITAL AMPLIFIER APPLIED TO THE ARMY ARTIFICIAL HEART PUMP

DDC Report AD602239 (Harry Diamond Labs - Washington, D. C.), April, 1964

A two-stage fluid amplifier was designed and evaluated for use with the Army Artificial Heart pump. The stages were of the digital type, having preestablished characteristics, such that their cascaded output is applicable to the heart pump. Tests showed that the two-stage amplifier yields total pressure recoveries up to 50 per cent. Output flows of the pump were considerably higher than those of a single-stage heart pump for similar input air pressures. However, the input air flow to the two-stage amplifier was also higher than that for the single amplifier. This high flow can be decreased by decreasing the nozzle areas of the two stages.

C-033

Cardon, M. H. (Bendix Corp.)

DESIGN, FABRICATION AND TEST OF A FLUID INTERACTION SERVOVALVE

NASA CR - 54463 - - Bendix Report BRLD No. 2978, prepared for contract NAS 3-5212, May 17, 1965

A laboratory model of a pneumatic-input servovalve that operates without the use of moving mechanical parts was built and tested. Interactions of fluid streams have been used instead of moving parts. This servovalve has the output characteristics of a four-way open-centered valve. The model was designed to operate with supply pressure of 5.16×10^5 N/M^2 g (75 psig) air and with standard atmosphere (14.7psia) exhaust. Tests demonstrated a 60 per cent pressure recovery and a 44 per cent flow recovery. The report presents design details, test results, and suggestions for improving performance.

C-034

Carafagno, S. P.; McCabe, J. T.

SUMMARY OF INVESTIGATIONS OF ENTRANCE EFFECTS IN CIRCULAR THRUST BEARINGS

Appendix E - Packed Column Flow Meters, Franklin Institute Interim Report
1-A2049-24, prepared for Contract NONR-2342(00), Task NR-062-316

A report that the pressure drop across a column of glass beads is a linear
function of flow rate under conditions of laminar flow made such a device appear
desirable for flow rate measurement in the entrance effects experiments. After
considerable experimenting with several flow meters of this type, it was
learned that their calibration did not remain adequately constant for the
purpose. Apparently, the packing density of the glass beads changed with use.
The experience of this experiment is recorded in this appendix for the benefit
of those who may consider the use of packed columns for flow rate measurement.

C-035

Cargill, N. A.; Reader, T. D. (Sperry Rand Corp.)

ELECTRO-SONIC FLUID AMPLIFIER

U.S. Patent No. 3,144,037 dated August 11, 1964, filed February 16, 1961

This invention relates to fluid amplifiers and more particularly to
means for electrically controlling the switching of the fluid stream within a
fluid amplifier. The present invention provides a vibrating diaphragm, in each
of the fluid control signal chambers found in conventional fluid amplifiers.
These diaphragms are selectively actuated by electrical means to produce the
fluid control signals which switch the amplifier.

C-036

Carlson, W. L., Jr. (Minneapolis-Honeywell Co.)

CYLINDRICAL FLUID AMPLIFIER

U.S. Patent No. 3, 039, 490 dated June 19, 1962, filed May 11, 1961

This invention is directed to a fluid control device known as the fluid
amplifier, and is more specifically directed to a fluid amplifier having a
cylindrical configuration as apposed to the usual flat configuration.

C-037

Carter, V.; Fine, Jonathan (Harry Diamond Labs.)

FLUID AMPLIFICATION TECHNOLOGY: A BIBLIOGRAPHY OF DIRECT CONTRIBUTIONS

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. III, May 26-28, 1964

    Contained in this bibliography are 143 citations of publications and patents considered contributory to the technology of "pure fluid amplifiers", that is, those fluid devices containing no moving parts and exemplified by the disclosures of Horton, Bowles, and Warren during the first half of 1959. Included are:

    1. Reports (industry and government)

    2. Theses

    3. Papers

    4. Articles (journals and periodicals)

    5. Patents

Approximately 80% of the material cited has been abstracted.

C-038

Carwile, Clifton L.

AN ANALYTICAL AND EXPERIMENTAL STUDY OF THE PRESSURE OF A SMALL CHAMBER TO FORCED PRESSURE OSCILLATIONS (Dated October 15, 1962)

Princeton University Aeronautical Engineering Report No. 595d

    The various resonant modes of gas pressure oscillations in a Sinusoidal Pressure Generator, featuring a closed, flat cylindrical chamber, were theoretically determined and verified experimentally, using Freon-12 and nitrogen as test media.

    For chamber length-to-diameter ratios less than 1.71 the transverse modes were shown to be dominant. Since the test chamber of the Sinusoidal Pressure Generator had a length-to-diameter ratio of only 0.38, it was predicted analytically that the lowest obtainable resonant frequencies would be the first and second tangential modes. Strong transverse nearly-sinusoidal waves corresponding to these two modes were obtained in the tests, but with frequencies somewhat less than those predicted by acoustic theory.

C-039

Cass; L. A; Comfort, E. H.; O'Conner, T. J.

TURBULENT MIXING OF AN AXISYMMETRIC JET OF PARTIALLY DISSOCIATED NITROGEN WITH AMBIENT AIR

See author O'Conner, T. J.

C-040

Chanaud, R. C.; Rodely A. E.; White, D. F. (American Radiator & Standard Sanitary Corp.)

A DIGITAL FLOWMETER WITHOUT MOVING PARTS

ASME Paper 65WA/Fm-6 presented at the Winter Annual Meeting Chicago, November 7-11, 1965

C-041

Charnley, C. J. and Bidgood, R. E.

FLUID UNITS OF THE BALL VALVE TYPE AND THEIR APPLICATION TO THE CONTROL OF A MACHINE TOOL

Cranfield Department of Production and Industrial Administration.

See author, Bidgood, R. E.

C-042

Charnley, C. J.; Bidgood, R. E.; Boardman, G. E. T.

THE DESIGN OF A PNEUMATIC POSITION ENCODER

Paper No. 1.5 presented at the IFAC/IFIP Symposium on Microminiaturization in Automatic Control Equipment and in Digital Computers - Held in Munich, Germany, October 21-23, 1965

     With the advent of fluid logic and amplification devices capable of performing switching actions in fluid circuits, it was felt that there were numerous applications in the field of automatically controlled machine tools in which these devices could replace electrical and electronic equipment. Although slower than their electrical counterparts, they promise to be cheaper, simpler and more reliable in suitable applications which include sequential control circuits and tape controlled "point-to-point" systems. This paper discusses the various methods which could be adopted for encoding position signals related to the movement of a machine slide or leadscrew and describes in detail the digital absolute circuit chosen for further research.

C-043

Charnley, C. J.; Bidgood, R. E.; Ramanathan (College of Aeronautics, Cranfield, U.K.

THE DESIGN OF A PNEUMATIC TAPE READER

Paper given at the First Conference on Fluid Logic and Amplification sponsored
by the British Hyromechanics Research Association and college of Aeron. Cranfield,
England, September 9-10, 1965

C-044

Chen, T. F.; Shook, T. A.; Reader, T.

FLUID AMPLIFICATION 12. BINARY COUNTER DESIGN

DDC Report AD617699 (Univac Division Sperry Rand Corp. for Contract DA49
186AMC34X), November, 1964

        See author Shook, T. A.

C-045

Chen, Y. N.

EXPERIMENTAL INVESTIGATION OF PRESSURE WAVES IN A MANIFOLD

Sulzer Technical Review, Research Number 1963 (Diesel Engines) Page 41

        The pressure waves arising in the exhaust flows of large internal combustion
engines are generally utilized for supercharging purposes. The pressure-wave
energy available for use in the turbocharger is affected by the cross-section of
flow in the latter and by the diameter, length and branches of the exhaust
manifold. Advance calculation of the conditions by the method of characteristics
is a very complicated matter. For this reason the pressure waves were investigated
experimentally in the Sulzer vibration laboratory in model pipes of various
lengths and cross-sections and with differing branch arrangements and nozzle
diameters, in order to obtain information on the useful energy of the waves
and thus to provide basic data for the design of diesel-engine turbocharger
systems.

C-046

Clayton, B. J.; Wetheral, T. G.

APPLICATION OF PURE FLUID COMPONENTS TO MISSILE CONTROL SYSTEM

Presented to Society of Automotive Engineers Aerospace Fluid Power Systems
and Equipment Committee Thrust Vector Control Panel 13 April, 1964

    The Army Inertial Guidance and Control Laboratory believes that pure fluid
control systems should be seriously considered for certain types of future Army
missile systems. The Test Missile with the roll rate damper control system will
be test flown at the Redstone Arsenal missile range within a few months. After
this test, the AIG&G Laboratory has plans for an optimized roll control system
using a different type of pure fluid control system. The future plans also
call for more sophisticated pure fluid two and three axes control systems.

C-047

Clayton, B. J., Williams, J. G. and Byrd, J. L.

DEVELOPMENT OF PURE FLUID MISSILE CONTROL SYSTEM (SUMMARY REPORT FY 62)

U. S. Army Missile Command Report No. RG-TR-62-7, 28 October, 1963

    See Author Byrd, J. L.

C-048

Clayton, B. J.; Posingies

THE DEVELOPMENT AND FLIGHT TEST OF A PURE FLUID MISSILE CONTROL SYSTEM

Paper presented at the A1AA/10N Guidance & Control Conference, August 16-18, 1965,
Minneapolis, Minnesota

C-049

Cochran, W. L.; Van Tilburg, R. W.

APPLICATION OF OPTICAL FABRICATION TECHNIQUES TO THE FABRICATION AND DEVELOPMENT
OF FLUID AMPLIFIERS.

DDC Report AD610586 (Corning Glass Progress Report for Period Ending October 31, 1963)

    See author Van Tilburg, R. W.

C-050

Cochran, W. L.; Van Tilburg, R W.

DEVELOPMENT OF A PROPORTIONAL FLUID AMPLIFIER FOR MULTI-STAGE OPERATION

Proceedings of the HDL 2nd Fluid Amplification Symposium Vol. II, May 26-28, 1964

See Author Van Tilburg, R. W.

C-051

Cochran, W. L.; Van Tilburg, R. W. (Corning Glass)

THE STAGING OF PRESSURE PROPORTIONAL AMPLIFIERS TO PROVIDE STABLE MEDIUM GAIN, DUAL CONTROL, SINGLE OUTPUT PURE FLUID SYSTEMS

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. II, May 26-28, 1964

Fabrication and testing techniques used in the development of multi-stage pressure proportional amplifier pure fluid systems are discussed and practical solutions to some of the problems inherent in the development of interconnected fluid subsystems are given where available. Performance of individual elements are discussed as they relate to staged system performance. Staged system noise and individual element noise is described and the attempts to locate and eliminate the sources of the noise are discussed. In each case, only those solutions which have been demonstrated as possible and practical are offered.

A solution to the problem of providing a common power inlet to a multistaged system is presented and the effect of using such a common source is discussed.

The description and output characteristics of a modified passive difference amplifier are given. The passive difference amplifier was originally designed by HDL personnel and when used in conjunction with a staged system provides a single pneumatic signal approximating the difference in pneumatic signals appearing at the outputs of the staged system. With the use of this device it is possible to have output signals which are compatible with the control signal requirements of the staged system.

C-052

Cohen, H; Watson, T. J.; Tu, Yih-O

A THEORETICAL MODEL FOR SEPARATION IN THE FLUID JET AMPLIFIER

Report A64-10761, Also IBM Journal of Research & Development, Vol. 7, October, 1963, Pages 288-296

C-053

Cohen, H. G; Alblas, J. B.

THE DEFLECTION OF TURBULENT JETS BETWEEN BOUNDING WALLS

See Author Alblas, J. B.

C-054

Coleman, D. D.; Gray, K. E. (Princeton, Inc.)

THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE COMPRESSIBLE FREE MIXING OF TWO DISSIMILAR GASES

Paper No. 65-822 at the AIAA Aerothermochemistry of Turbulent Flows Conference Held December 13-15, 1965

An extension and improvement of Warren's momentum integral method for predicting the turbulent mixing and decay of axially symmetric, compressible, free jets to the case of the mixing of dissimilar gases is discussed. Two ideal gases having different molecular weights and specific heats are treated with the assumption that the local turbulent mixing rate at each axial location depends upon a suitably chosen local reference Mach number. This method of analysis is then compared with the results of a series of jet mixing experiments carried out on helium, methane, nitrogen, carbon dioxide, and freon jets mixing in air. Mach numbers, ranging from 0.75 to 3.30 were investigated. The character and mixing rates of both properly and improperly expanded supersonic flows were studied. It is concluded from a comparison of these data with the theoretical method presented that a general relationship exists between a local mixing rate parameter and the local Mach number at each axial position in the jet where the velocity has fallen to 1/2 of its centerline value. This general relationship is independent, within the accuracy of these experiments, of the physical properties or the thermodynamic state of the mixing gases.

C-055

Colston, J. R. (Bowles Engineering Corporation)

A PNEUMATIC PURE FLUID SPEED CONTROL FOR A 500 KW STEAM TURBINE GENERATOR

Office of Naval Research Power Branch Report, September, 1963

A Pneumatic Pure Fluid Speed Control was designed and constructed for a 500 KW steam turbine generator. Its performance was demonstrated in a laboratory bench test on a scaled system. The unit met the specification for 1/2% speed control for a 10% load change. The report covers the selection of a suitable system, a description of the performance of each component, and a summary of the test results.

C-056

Colston, J. R.; Dexter, E. M.

APPLICATIONS OF PURE FLUID TECHNIQUES TO A SPEED CONTROL

Proceedings of the 2nd Fluid Amplification Symposium Vol. II, May 26-28, 1964

Pure fluid controls are attractive as speed controls because they reduce mechanical complexity which reduces cost and improves reliability. These controls can use the fluids which already are available in the system. This paper is concerned with an application for the Office of Naval Research where the objective is a 500 KW power plant using the steam for the control and for bearings; thus eliminating the need for electromechanical devices and a second fluid completely.

C-057

Colston, John R.

A PURE FLUID SPEED GOVERNOR

Presented at a meeting of the Society of Automotive Engineers on April 14, 1964, at Phoenix.

This turbine speed governor demonstrates the advanced state of the art of analog Pure Fluid systems. This feasibility model was designed, built and met design specifications without any modifications of the Pure Fluid circuits. This accomplishment serves to show the major advances which have occurred in analytic design of Pure Fluid systems since its initiation in 1959.

The most important factor is that Pure Fluid systems offer a reliability and performance capability not previously available to the control system engineer.

C-058

Comfort, E. H.; Cass, L. A.; O'Connor, T. J.

TURBULENT MIXING OF AN AXISYMMETRIC JET OF PARTIALLY DISSOCIATED NITROGEN WITH AMBIENT AIR

See O'Connor, T. J.

C-059

Comparin, R. A. (IBM Co.)

PNEUMATIC SWITCH

U.S. Patent No. 3, 139,895 dated July 7, 1964, filed November 29, 1961

This invention relates to fluid switches, and more particularly to those employing control ports selectively chargeable with pressure fluid for diverting a main fluid stream to a corresponding outlet. It is known to provide a switch of the above general type for diverting pressure fluid to either of two outlets.

C-060

Conesco Inc., Cambridge, Mass.

DEVELOPMENT OF NOISE MEASUREMENT TECHNIQUES AND PROCEDURES FOR USE IN FLUID PIPING SYSTEMS

Report AD607588, Conesco Report F-123-1 , for Contract NOBS 88557, April, 1964

The report presents the results of experimental and theoretical studies of four aspects of acoustic measurements in piping systems. The first deals with the effects of air in the system. The second deals with the use of transparent plastic test systems, and the third and fourth studies deal with the background levels associated with turbulent fluid flowing past a hydrophone and with the generation of acoustic signals by high velocity flows through devices which are meant to act as attenuators.

C-061

Connaught, P. M. (Robertshaw Controls Company)

PNEUMATIC THYRATRONS

U. S. Patent No. 3,150,674 dated September 29, 1964, filed December 28, 1961

This invention relates to pneumatic control devices and more particularly to pneumatic switching devices which are analogous to and have substantially identical caharcteristics as an electronic thyratron. It is an object of this invention to provide a pneumatic device having structure which is a mechanical analog of an electronic thyratron.

C-062

Conrad, Peter W.

THE EFFECTS OF ROTATION ON THE STABILITY OF LAMINAR BOUNDARY LAYERS ON CURVED WALLS

The purpose here is to study the stability, relative to small distrubances, of boundary layers over slightly curved walls which are rotating about an axis perpendicular to both the flow direction and the radii of curvature. The primary interest is in the neutral stability case (no amplification) for which an eigen value problem is developed which will yield a critical Reynolds number for each combination of rotation, curvature and frequency of the disturbance. Results are given for various intermediate frequencies along with a limiting value for the zero frequency case and a qualitative argument concerning the trend for high frequencies, for several combinations of curvature and rotation.

C-063

Contractor, D. N.; Cain, John

A NOTE ON THE DESIGN OF FLEXIBLE-WALL, VOLUME RESONATOR ACOUSTIC FILTERS

The behavior of flexible-wall, volume-resonator acoustic filters in liquid-filled pipes can be predicted accurately over a wide frequency range by means of existing theory. However, for design purposes, a simple method for the selection of the major parameters of the filter and the effect of the variation of these parameters upon the filter performance, needs to be made available. Results are presented herein which will enable one to select an approximate value of the attenuation parameter for given requirements. Additional results show the effect of the variation of the tail pipe parameter on the filter performance. These findings aid in the proper placement of the filter from the open end of the pipe. Experimental results of tests on a resonator filter with three different connectors are presented.

C-064

Contractor, D. N.

PRELIMINARY STUDIES OF THE SOUND GENERATED BY ORIFICES IN PIPELINES

DDC Report (Hydronautics Inc. Laurel, Md.) Contract NOBS88200, February, 1964

The sound generated by orifices in pipelines was studied both analytically and experimentally. At low Mach numbers, the sound is generated by mass flow fluctuations caused by the periodic formation and shedding of vortices from the orifice edge. The sound produced has pure tones at a characteristic frequency and its lower and higher harmonics. At higher Mach numbers, the sound has a broad frequency base and is generated by the fluctuating force exerted by the orifice plate on the fluid. The study was extended to the noise generated by multiple orifices in the orifice plate. Experimental results are presented that verify the above analyses. Spectral density curves are given for the two types of sound generating mechanisms.

C-065

Cox, J. E.

THE VISCOUS DISSIPATION OF ENERGY IN FREE TURBULENT FLOWS OCCURRING IN FLUID AMPLIFIER OPERATION

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-27-28, 1964

A discussion of the solutions of the equations of motion and the energy equations is presented for the cases of free turbulent flows occurring in fluid amplifier operation. The effect of turbulent viscosity on these two equations is discussed. In order to determine the effects of the viscosity on the energy equation, the mechanism of the viscous dissipation of energy must be investigated. Evaluating the dissipation function independently provides expressions for the distribution of the viscous dissipation of energy. To illustrate the evaluation techniques involved, the simple case of the jet boundary is considered in detail.

C-066

Craft, D. J. (British Telecommunications Research Limited, U. K.)

MEASURING TECHNIQUES FOR FLUID DEVICES

Paper given at the First Conference on Fluid Logic and Amplification sponsored by the British Hydromechanics Research Association and College of Aeron. Cranfield, England , September 9-10, 1965

C-067

Crocco, Luigi, Cheng, Sin - I

THEORY OF COMBUSTION INSTABILITY IN LIQUID ROCKETS

Butterworths Publications Ltd. - London, 1956

C-068

Cronin, Richard T.

A HYDRODYNAMIC STUDY OF THE FREE-JET CLASS OF FLUID JET AMPLIFIERS

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-28, 1964

A theoretical two-dimensional solution is presented for the free-jet class of fluid-jet amplifiers. As a preliminary investigation, it is assumed that both the primary and secondary streams of perfect fluid are guided by two-dimensional channels with straight and parallel walls. The deflection angle and the free streamline profile of the resulting jet are solved by using "Free Streamline Theory" of Kirchhoff.

The jet deflection angle has been related in closed form to both channel flows, both channel widths, the included angle between the channels, the jet flow and its speed. The amplifier geometrical configuration is completely specified when certain mapping equations, usually requiring numerical integration, yield the free streamline profile of the jet and the coordinates of both channel exits.

C-069

Curtiss, H. A.; Zisfein, M. B.

A HIGH GAIN PROPORTIONAL FLUID STATE FLOW AMPLIFIER

Proceedings of the HDL 2nd Fluid Amplification Symposium Vol. I, May 26-28, 1964

See author, Zisfein, M. B.

C-070

Curtiss, H. A. Liquornik, D. J.

RESEARCH STUDIES IN PROPORTIONAL FLUID STATE CONTROL COMPONENTS, PART 2

DDC Report AD-618103 (Astromechanics Research Division Giannini Controls, Report ARD-TR-013-02, Contract DA360340RD3722RD, March, 1965)

Results of experimental research performed on the double leg elbow amplifier (DLEA) are presented. The DLEA with a straight active leg, was operated in a closed configuration. Tests were conducted with hot gas as a working medium, and two amplifiers were coupled and tested as a two stage amplifier. The DLEA was optimized for power gain. In addition, analytical techniques were expanded to include the effect of the splitter on the DLEA performance. It was concluded that the optimized double leg elbow amplifier would be excellent in control applications demanding high mass flow gains and high power gains especially when used to control gasses at extremely high temperatures.

C-071

Curtiss, H. A.; Feil, O. G.; Liquornik, D. J.

SEPARATED FLOW IN CURVED CHANNELS

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-28, 1964

This report presents some results of a fundamental experimental study of separating curved channel flow both with and without secondary injection. Some of these results are compared with a preliminary analytical technique based on an empirically modified classical approach. The complex nature of the flows involved precludes the early derivation of a completely general theory. A discussion of published literature applicable to separating curved flow shows that very little prior work, either theoretical or experimental, has been reported; and that, to the authors' knowledge, nothing has been reported on secondary injection into this type of flow. A method for predicting the flow redistribution resulting from secondary injection into a straight channel is presented in this report and compared with the experimental results.

C-072

Curtiss, H. A, Feil. O. G; Liquornik, D. J. (Giannini Controls)

SEPARATED FLOWS IN CURVED CHANNELS WITH SECONDARY INJECTION

Injection of secondary fluid flow into a primary flow confined in a curved or straight channel is shown to be a powerful technique for use in fluid state amplification. The secondary injection continuously and progressively alters the separation characteristics of the confined primary flow, resulting in large proportional changes in the channel output flows. A fundamental experimental study of the method with incompressible, turbulent boundary layer flow in a range of varying curvature channels, was conducted to learn about the flow characteristics and passage shape parameters relevant to proportional amplification. Several injection methods and velocities were investigated with the main emphasis on the effects of this injection on the flow characteristics within the channels. Preliminary analytical techniques which compared favorably with the experimental results were developed. An overall comparison of the mass flow and momentum gains obtainable for various injection and channel configurations is presented.

D-017

Dahm, W.; Hanson, A.; Larson, R.; Krause, F.

HEAT TRANSFER BELOW REATTACHING TURBULENT FLOWS

See Author Krause, F.

D-018

Dawson, R. J. (North American Aviation)

FLUID POWER

Space Aeronautics, Vol. 42, September, 1964, Pages 109-112

Discussion of pneumatic and hydraulic power systems. Hot-gas systems, which use the motor-bleed gas with a high solids content and flame temperatures of 5000-6000°F, are said to represent the most advanced kind of pneumatic system now used in aerospace. Warm-gas systems, operating on the low-energy propellants used in gas generators, which have a low solids content and flame temperatures of 1800-2300°F, appear to be quite competitive with other types of thrust vector control provided there is enough space for the propellant they require. The use of digital hydraulics with incremental instead of analog outputs is being studied. The basic pure-fluid amplifier is shown in a diagram and discussed. A development program is underway whose aim is a centrifugal pump suitable for use with Oronite 8200 at 600°F in future power-transmission systems. Bis-(phenoxyphenoxy) benzene, phenyl methyl silicone, deep-dewaxed mineral oil, and an ester of trimethyolpropane for use as hydraulic fluids at 700°F have been evaluated, with the first one being considered for temperatures above 700°F. Liquid metals are being considered for use in power-conversion systems. Brazed permanent joints are preferred for use in tubing in the hydraulic system.

D-019

de Bruyne, N. A. (Techni, (Cambridge) LTD Dufford U. K.)

PNEUMATIC NOR BLOCKS

Paper given at the First Conference on Fluid Logic and Amplification sponsored by the British Hydromechanics Research Association and College of Aeron. Cranfield, England, September 9-10, 1965

D-020

Defense Documentation Center

FLUID AMPLIFICATION: A REPORT BIBLIOGRAPHY

DDC Report AD-472500, October, 1965

This report bibliography was prepared by DDC on Fluid Amplification for the 3rd Fluid Amplification Symposium, which was held October 26-28, 1965 at the Harry Diamond Laboratories.

The purpose of the abstract compilation is to identify and acquaint symposium attendees and DDC users with the Department of Defense sponsored literature on fluid amplifiers and closely related research areas.

The references were obtained by a computer search with DDC descriptors; the product of this computer search was then manually refined. Computer-produced indexes (subject, personal, author, contract number) are presented. Bibliographic entries are in numerical sequence by AD number.

A classified version of the Fluid Amplification bibliography will be produced and made available to qualified DDC users upon request. The reference number is AD-366 900. All unclassified/unlimited documents may be obtained by the public from the Clearinghouse for Federal Scientific and Technical Information (CFSTI).

D-021

Deissler, R. G; Perlmutter, M.

AN ANALYSIS OF THE ENERGY SEPARATION IN LAMINAR AND TURBULENT COMPRESSIBLE VORTEX FLOWS

Paper from the Lewis Flight Propulsion Laboratory NASA - Cleveland, Ohio

The problem considered in this paper is that of the velocity and temperature distributions in a viscous vortex with radial and axial flow. A summary of the work done between 1931 and 1953 is given. It appears that there is a need for a systematic analysis based on the equations of motion and energy, and which includes the important effects.

D-022

Denker, R. E. (Whittaker Controls and Guidance)

THEORETICAL ANALYSIS OF FLUID AMPLIFIER DESIGN

Proceedings of the HDL Fluid Amplification - Second Symposium, Vol. II, May 26-28, 1964, N64-23820

This paper develops a formula which interrelates the major factors involved in a pneumatic bi-stable amplifier that operates above critical pressure ratios. The formula enables accurate scaling of a design and indicates the direction required for optimization. The analysis is based upon techniques that are used in the missile components industry for design of submerged pneumatic flow systems.

D-023

Dexter, E. M.; Bowles, R. E., Dr.

A SECOND GENERATION OF FLUID SYSTEM APPLICATIONS

See Author, Bowles, R. E., Dr.

D-024

Dexter, E. M.; Colston, J. R.

APPLICATIONS OF PURE FLUID TECHNIQUES TO A SPEED CONTROL

See Author, Colston, J. R.

D-025

Dexter, E. M.; Jones, D. R. (Bowles Engineering Co.)

BIAS DEVICE FOR PURE FLUID AMPLIFIER

U. S. Patent No. 3,209,775 dated October 5, 1965, filed December 7, 1962

This invention relates generally to pure fluid amplifying systems and more specifically to a mechanism for selecting, nullifying or creating a variable bias condition in a pure fluid amplifying system.

D-026

Dockery, R. J.; Katz, Silas; Goto, J. M.

EXPERIMENTS IN ANALOG COMPUTATION WITH FLUIDS

See Author Katz, Silas

D-027

Dockery, R. J.; Katz, Silas

STAGING OF PROPORTIONAL AND BI-STABLE FLUID AMPLIFIERS

See Author Katz, Silas

D-028

Dodson, G. C.; Rivest, E. L.; Wood, D. E. (GE Co.)

SIGNAL PROCESSING AND WAVEFORM PATTERN RECOGNITION FOR -- ANALYSIS OF SIGNAL ORIGINS INSTRUMENTATION AND AUTOMATION

GE TIS Report 65-C-041 dated September 14, 1965

See Author Wood, D. E.

D-029

Donnelly, R. J.; Schwarz, K. W.; Springett, B. E.

MODES OF INSTABILITY IN SPIRAL FLOW BETWEEN ROTATING CYLINDERS

See Author Schwarz, K. W.

D-030

Dosanjh, Darshan, S.; Sheeran, William J.

INVESTIGATIONS OF INTERACTING UNDEREXPANDED JET FLOWS

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. I, May 26-28, 1964

See Author Sheeran, W. J.

D-031

Drohan (Univac)

UNIVAC SHOWS SYSTEM USING FLUIDS FOR LOGIC ELEMENTS

Electronic News, October 19, 1964, Page 34

D-032

D'Sonza, A. F.; Oldenburger, R.

DYNAMIC RESPONSE OF FLUID LINES

Journal of Basic Engineering, Trans. ASME, September, 1964, Pages 589-598

D-033

Durbov, A; Makarov, I.

ELECTRONICS, NEW RIVAL

    See Author Makarov, I.

D-034

Ducoffe, A. L. and White, F. M., Jr.

THE PROBLEM OF PNEUMATIC PRESSURE LAG
PART 1 - Steady-Stage Flow in a Tubing System

Paper No. 63--AHGT-6, Transactions of the ASME Journal of Basic Engineering.

    An analytical and experimental investigation of the steady-state isothermal flow in a series system, comprised of a constant-diameter tube with reduced size unions located at the tube extremities, is reported herein.

    The pressure drop across the system has been determined experimentally as a function of the system geometry. The parameters chosen for investigation were the tube length to diameter ratio L/D, the union diameter to tube diameter ratio D_f/D, and the Reynolds number. The ranges of the parameters investigated consisted of $159 \leq L/D \leq 1475$, $0.7 \leq D_f/D \leq 1.0$, and $200 \leq$ Reynolds number $\leq 100,000$. All tests were conducted at room temperature.

    The theory is derived considering each geometric element of the system, such as inlet, development length, exit, and so on, and a set of five simultaneous algebraic flow equations results. Solutions to these were obtained by use of a digital computer. A pseudo-friction factor, for fully-developed laminar or turbulent flow, is defined. The result indicates that the correlation of theory with experiment is quantitative over the range of parameters investigated.

D-036

Duff, J.; Foster K; and Mitchell, D. G. (University of Birmingham U. K.)

SOME EXPERIMENTS ON THE VORTEX VALVE

Paper given at the First Conference on Fluid Logic and Amplification sponsored by the British Hydromechanics Research Association and College of Aeron. Cranfield, England, September 9-10, 1965

D-037

Dunaway, J. C.; Ayre, V. H. (Redstone Arsenal)

A STATUS REPORT ON THE EXPERIMENTAL DEVELOPMENT OF A HOT GAS VALVE

Proceedings of the 2nd Fluid Amplification Symposium, Vol. II, May 26-28, 1964

This report describes an effort toward development of a hot gas jet reaction valve utilizing boundary layer technique to control a high pressure, high temperature gas stream. The result of this program to date has been the successful design of a hot gas valve in a reaction control system utilizing fluid-controlled bi-stable amplifier principles, requiring no moving parts in the gas stream and no source of secondary pressure.

Valves have been fabricated and successfully tested with gases at pressures to 1300 psi and temperatures to 2350°F. with flow rates to 1#/sec. cold air.

This status report on the program presents a summary of results of experimental design work completed and a review of packaging and environmental problems with an existing missile system.

D-038

Dunaway, J. C. Ayre, V. H.

DEVELOPMENT OF A HOT GAS BI-STABLE JET REACTION CONTROL VALVE

See Author Ayre, V. H.

E-007

Earles, S.W.E.; Zarek, J. M. (University of London)

REFLECTION OF PRESSURE WAVES AT SHARP-EDGED ORIFICES

The work described is part of an investigation into the problem of metering unsteady gas flow in pipes by means of sharp-edged orifices. However, it is possible that the results of this investigation may have a wider interest for instance in problems connected with the study of pulse-pressure charging and scavenging of two-stroke engines. The magnitude is measured of the reflected pressure wave resulting from a pressure wave striking a sharp-edged orifice situated at the end of a pipe containing initially a stationary column of air. The experimental results obtained for orifice to pipe diameter ratios of 0.375, 0.50, 0.675, 0.75, 0.875 and 1.00 subjected to advancing pressure wave amplitudes of between 0-7.6 lbf/in^2 above atmospheric are compared with theoretical results obtained by Nesbitt using the method of characteristics. The comparison of the experimental and theoretical results suggest that the assumption made by Nesbitt i.e. "the static pressure of the issuing jet remains constant" may not be correct and that converging of the jet takes place resulting in a vena contracta effect. This effect has been called the "reflection coefficient of contraction" and has been shown to have some possible influence on the overall coefficient of discharge for the metering of pulsating gas flow.

E-008

Eggers, G.; Ernst, G. (France)

JET CONTROL APPARATUS

This invention relates to the control of the jets provided by propulsive units and other apparatus, more particularly directional control (deviation) and the adaption of the nozzle by control of the throat in the case of supersonic jets.

E-009

Eige, J. J. (Stanford Research Institute)

MULTIPLE-BALL PNEUMATIC AMPLIFIERS

A new class of fluid amplifier has been devised in which a balance of forces on balls of two sizes valves air-pressure signals. The few simple parts allow high input flow resistance, low output resistance, low power dissipation, visual indication of state, and compatibility with a variety of outputs including bellows, nozzles, and electrical contacts.

Two balls form a logical inhibitor, and three balls comprise a two-input NOR, either element being sufficient to combine in networks for all binary logic functions. A wide range of size and pressure level is possible. Units have been made as small as 0.04 in.^{3} per NOR with interconnections. Power consumption of 10 milliwatts and switching times of 1.7 milliseconds have been measured. Ball diameters of from 1/16 to 3/8 in. are representative. Supply pressures have ranged from 0.1 to 100 psig.

The two-ball element can also be combined with flow restrictors to act as an operational amplifier for analog summing and integrating. All-solid parts of a variety of materials can tolerate high temperature and hard radiation.

E-010

Eisenberg, N. A. (Harry Diamond Labs)

A PNEUMATIC TAPE - READER

The tape-reader described in this paper uses flueric devices. The tape-reading system comprises two interlocking subsystems, the main logic subsystem and the control subsystem. The primary task of translating the tape falls to the main logic subsystem, which converts the pattern of holes in the tape into pneumatic signals, amplifies these signals, feeds the amplified signals into decoding elements, and actuates the typewriter.

In general the performance of the tape-recorder was good. Tapes could be read at about ten characters per second with few errors. This is about twice the speed of existing pneumatic tape readers and about the normal operating speed of electric tape readers.

E-011

Erian, F., Eskinazi, S.

THE WALL JET IN A LONGITUDINAL PRESSURE GRADIENT

DDC Report AD607474 (Syracuse University Research Institute) Contract NONR669 16 October, 1964

The objectives of the work are two-fold. First, its studies the effect of a longitudinal pressure gradient on the nature of the shear stress distribution, as well as the mechanism of energy-production. Secondly, it explores to find out if the existence of pressure gradients increased, in the flow field. The size of the negative energy-production region. The flow pattern used in conducting the present experiments was composed of a half-jet blowing out of a narrow vertical slot of large aspect ratio. The jet was bounded by a smooth rigid flat wall on one side, and mixing with a slower stream of air on the free side. A convergent then divergent passage was provided for the entire flow by placing a half symmetrical Joukowski Airfoil section on the free stream side of the wind tunnel. This airfoil section not only created a longitudinal variation in the free stream velocity, but also a pressure gradient which changed sign from negative in the convergent part of the passage to positive in the divergent part.

E-012

Ernst, G.; Eggers, G. (France)

JET CONTROL APPARATUS

U. S. Patent No. 3,036,430 dated May 29, 1962, filed June 16, 1959

See Author Eggers, G.

E-013

Escher Wyrs & Company, Zurich (Patentee)

JET CONTROLLER

Swiss, Patent: Published December 16, 1932, applied for June 6, 1931, granted October 15, 1932

Jet Controller in which a jet emerges from a power nozzle and is received by a receiver. This is accomplished by a secondary fluid stream which, depending on strength and direction, influences the main stream.

E-014

Eskurazi, S.; Erian, F.

THE WALL JET IN A LONGITUDINAL PRESSURE GRADIENT

　　See Author Erian, F.

E-015

Evans, R. A. (Honeywell Co.)

APPLIED FLUIDS TECHNOLOGY

Paper No. 650600 presented at the SAE/NASA - Conference - Aerospace Vehicle
Flight Control Conference, Los Angeles, July 13-15, 1965

　　Beginning in 1958, much effort has been applied toward the advancement of
"Fluid Technology." In early 1961, a step input occurred when the successful
development of a fluid rate sensor confirmed the promise of obtaining complete
fluid control and guidance systems without the use of moving parts. In the past
three years, major strides, in the form of actual hardware accomplishments have
been made toward realizing this goal. In fact, simple stabilization and control
systems were flight tested as far back as 1962. The "hardware" state of the art
of "fluids has progressed to a point that military and commercial problems can
now be solved by fluid systems, particularly those applications involving
destructive environmentals, long storage life, reliability, and low cost. This
paper summerizes the present state of the art with emphasis on actual hardware
developed specifically for system application. This is accomplished by presenting
a composite flight control system around which fluid components, from prime
sensors to actuators are discussed.

E-016

Evans, R. A. (Honeywell Co.)

CONTROL APPARATUS

U. S. Patent No. 3,171,422 dated March 2, 1965, filed July 10, 1962

　　This invention pertains to a proportional fluid amplifier which produces
an output signal in one of two output passages, which is proportional to the
control signal. This fluid amplifier control means provides a static pressure
output signal which substantially eliminates the aerodynamic noise and sub-
stantially reduces the time lag associated with the output signal.

E-017

Evans, Richard A

FLUID TECHNOLOGY: A STATE-OF-THE-ART REPORT

SAE Journal, September, 1965, Page 90

Seven years after its inciption, fluid flow offers some advantages for control systems, and promises more for the future, but much work remains to be done.

F-009

Falconer, D. G.

VALVES AND FLUID AMPLIFIERS

U.S. Patent No. 3, 147, 668 dated September 8, 1964, filed November 10, 1960

This invention relates to fluid amplifiers and valves in general and particularly those which utilize the forces of the fluid which they control for operation.

F-010

Farron, J. R.; Niehaus, D. J.; Burton, G. T. Jr.

FLUID-STATE CONTROL SYSTEMS FOR AEROSPACE NUCLEAR PROPULSION APPLICATIONS

See Author Burton, G. T., Jr.

F-011

Feil, O. G.; Liquornik, D. J.; Curtiss, H. A.

SEPARATED FLOW IN CURVED CHANNELS

See Author Curtiss, H. A.

F-012

Feil, O. G. Liquornik, D. J.; Curtiss, H. A.

Separated Flows in Curved Channels with Secondary Injections

See Author Curtiss, H. A.

F-013

Fiebig, Martin

ON THE MOTION WITHIN FLUID GYROSCOPES

DDC Report AD-608703 (Aeronautical Research Associates of Princeton, Inc. for Contract AF49638 1262), August, 1964

The flow field which results from the disturbance of an initially laminar, viscous, incompressible sink flow through a cylindrical chamber is investigated. The disturbance considered may arise either from an impulsive motion or a harmonic oscillation of the device perpendicular to its axis of symmetry. The results of this investigation indicate the general behavior of the response of the flow field within such a device over a wide range of the governing parameters. In particular, it is shown that the mean time-or phase-lag of the motion is nearly identical with the inviscid transport time, while the mean amplitude of the response is almost proportional to the inverse distance from the axis when the visco-geometric parameter is smaller than 1/10. Hence, such devices may possibly be used to detect extremely small rates of rotation and may act in a certain sense as excellent gyroscopes.

F-014

Fine, Jonathan; Carter, V.

FLUID AMPLIFICATION TECHNOLOGY: A BIBLIOGRAPHY OF DIRECT CONTRIBUTIONS

See Author Carter, V.

F-015

Fine, J. E. (Harry Diamond Lab)

SCHLIEREN OBSERVATIONS OF THE EFFECT OF SOUND INJECTED INTO THE POWER NOZZLE OF A HELIUM - INTO-AIR JET.

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. IV, October, 1965

The effect of sound on a jet of helium exhausting into air at ambient pressure and room temperature was investigated on the HDL Schlieren apparatus.

Acoustic signals from 50 to 4000 cps injected into a tank upstream of the nozzle caused a laminar jet to break up into turbulence or the transition region of a turbulent jet to move upstream.

The results indicate that the region of jet sensitivity is within the region of jet instability as described by Chanaud and Powell.

F-016

Fisher, M. J.; Prosser, D. W.

SOME INFLUENCES OF TURBULENCE ON THE NOISE OF PROPORTIONAL FLUID AMPLIFIERS

Proceedings of the HDL Fluid Amplification Symposium, Vol. II, October, 1965

See Author Prosser, D. W.

F-017

Fix, J. W.; Kaufman, W. F.; Hallum, C. E.

A PURE PNEUMATIC REGULATOR

See Author Kaufman, W. F.

F-018

Foss, John F., Jones, J. B.

A STUDY OF INCOMPRESSIBLE BOUNDED TURBULENT JETS

DDC Report AD-611189 (Purdue Research Foundation report for Contract DA83DAMXDO CSA40/ November, 1964)

The purpose of the investigation was twofold. First, studies were directed toward the establishment and investigation of the three-dimensional effects of a single-bounded jet flow between parallel plates. Second, an investigation was made of the jet interaction problem which is the governing factor in all proportional fluid amplifier devices and is an important factor in the operation of bistable amplifier elements. Tests were conducted on jet deflection, mean flow, and the effects of nozzle geometry and momentum flux ratios.

F-019

Foster, Hampton H.; Heidmann, Marcus F.

EFFECT OF IMPINGEMENT ANGLE ON DROP-SIZE DISTRIBUTION AND SPRAY PATTERN OF TWO INPINGING WATER JETS

Technical Note D-872 (NASA), Lewis Research Center, Cleveland, Ohio

Sprays produced by two 0.089-inch-diameter jets at impingment angles of 10° to 90° and jet velocities of 30 to 74 feet per second were studied. Drop-size distributions for sprays formed in 100-foot-per-second air are presented. Distributic were bimodal in character, and the effects of test conditions on the bimodal propertie are presented. Photographs of the overall spray pattern produced in quiescent air are also shown.

F-020

Foster, Hampton H. and Heidmann, Marcus F.

SPATIAL CHARACTERISTICS OF WATER SPRAY FORMED BY TWO IMPINGING JETS AT SEVERAL JET VELOCITIES IN QUIESCENT AIR

NASA Technical Note D-301, Lewis Research Center, Cleveland, Ohio

Sprays formed by two 0.089-inch impinging water jets in quiescent air were studied for a range of jet velocities typical of those used in current rocket engine design practices. A survey around the point of jet impingement was made with photographic techniques. The spray velocity varied from 99 to 72 per cent of the jet velocity as the radial position changed from the spray axis to $\pm 80^{\circ}$ positions. Fifty per cent of the mass was distributed about the spray axis in an included angle of 40°. A mass mean drop size of 54 per cent of an extrapolated maximum was indicated.

F-021

Foster, K., Jones, N. S. (University of Birmingham, U.K.)

AN EXAMINATION OF THE EFFECT OF GEOMETRY ON THE CHARACTERISTICS OF A TURBULENT RE-ATTACHMENT DEVICE

Paper given at the First Conference on Fluid Logic and Amplification, September 9-10, 1965 sponsored by the British Hydromechanics Research Association and the College of Aeron. Cranfield, England.

F-022

Foster, K.; Mitchell, D. G.; Duff, J.

SOME EXPERIMENTS ON THE VORTEX VALVE

See Author Duff, J.

F-023

Foster, K; Misra, A. K. (University of Birmingham, U. K.)

THE TURBULENT REATTACHMENT AMPLIFIER IN A CONVENTIONAL PNEUMATIC CIRCUIT

Paper given at the First Conference on Fluid Logic and Amplification sponsored by the British Hydromechanics Research Association and College of Aeron. Cranfield, England, September 9-10, 1965.

F-024

Fox, H. L.; Goldschmied, F. R.

BASIC REQUIREMENTS FOR AN ANALYTICAL APPROACH TO PURE FLUID CONTROL SYSTEMS

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-28, 1964

The first type of pure fluid amplifier is classified as a planar device and some of the associated analytical and experimental problems are discussed. Another type of planar device based on the edge tone phenomena is described and its operation related to the same analytical and experimental problems.

A new approach to pure fluid device design using axisymmetric geometry is discussed. The same set of problems are then related to the axisymmetric class of fluid devices. In particular, it is shown how the focussed jet axisymmetric fluid device greatly simplifies analytical work.

The work of Fromm and Harlow is displayed as a means of solving the Navier-Stokes equations for the time dependent two-dimensional viscous case. The impact of this new approach in device design and analytical techniques is discussed.

F-025

Fox, H. L.; Goldschmied, FR; Letham, D. L.

FLUID AMPLIFIER DYNAMIC CHARACTERISTICS, Vol. II

NASA-CR-57349 (Sperry Utah Co. Final Report on Contract NAS8-11236), December 30, 1964

Those aspects of dimensional analysis and similarity of most pertinence to fluid circuitry are discussed. The equations of fluid flow through both orifices and circular tubes are given and discussed. The equivalent parameters of passive fluid elements are presented, both steady state and small signal. The instrumentation of fluids is discussed both for steady-state and time-dependent measurements. Typical active devices are described, discussed, and compared. Specific attention is given to the impact modulator and its use in operational amplifiers. An equivalent circuit for the impact modulator is found. The subject of circuit snythesis, and particularly transfer function synthesis is discussed. The requirements of proportional fluid circuitry are discussed and the use of equivalent circuits in the analysis of fluid circuits is presented through the discussion of specific circuits. Both steady-state and time varying examples are given. The loop transfer function of an idealized, but typical, fluid control circuit is presented and analyzed by the use of a Bode plot.

F-026

Fox, Harold L. and Wood, O. Lew

FLUID COMPUTERS

International Science and Technology, November 1963, Pages 44-50

The idea of a computer operating on jets of water or air in this day of electronic sophistication seems at first glance to be too silly to even consider. Yet the flow of fluids has recently been shown capable of performing the same logic functions as the "flow" of electricity and with a good deal less sensitivity to environmental factors such as radiation, heat, and vibration. The interaction of fluid jets with each other and with the walls of the devices containing them provides a stable system for digital processing. Also standard criteria for material selection for the devices ensure their stability, as well as the possibility of cheap, mass-produced logic systems.

F-027

Foxwell, J. E.; Holmes, A. B.

A DEVELOPMENT REPORT IN A FLUID AMPLIFIER ATTITUDE CONTROL

See Author Holmes, A. B.

F-028

Foxwell, J. E.; Holmes, A. B.; Sieracki, L. M.; Campagnuolo, C. J.

APPLICATION OF FLUERICS TO MISSILE ATTITUDE CONTROL

See Author Campagnuolo, C. J.

F-029

Foxwell, J. E. Jr.; Holmes, A. B.

SUPERSONIC FLUID AMPLIFICATION WITH VARIOUS EXPANSION RATIO NOZZLES

See Author Holmes, A. B.

F-030

Frantz, W. (Martin-Marietta)

INCREMENTAL DIGITAL FLUID ACTUATOR

U. S. Patent No. 3,164,065 dated, January 5, 1965, filed December 29, 1961

This invention relates to a digital hydraulic actuator and more particularly to a device having an input arrangement for directly accepting binary output signals from a digital computer, and causing motion to take place in discrete increments in accordance with the computer signals.

F-031

French Certificate of Inventors

PNEUMATIC OR HYDRAULIC REGULATING AND CONTROL SYSTEM

Patentee Fluid Controls Lab of the Institute of Automation and Remote Control of the Academy of Sciences, U.S.S.R., requested December 31, 1959, Granted September 5, 1960

F-032

Frey, K.P.H. & Vasuki, N. C.

Flow Stability for Two-Dimensional Cusp Devices

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965

In a previous paper the authors had used sequence photography to present the flow starting from rest to steady state of flow for various kinds of sudden enlargements. A cusp diffuser was included in these studies to clarify the behavior of cusp diffuser models from that of other sudden enlargements as predicted by the potential vortex motion theory. The tests were conducted in a new facility, the versatile flume, in order to get the first comparable results under conditions where unnecessary interactions at decisive locations of cusp diffusers could be avoided. The primary interest in these studies was to gain more information on transitions of varying stability of flows.

F-033

Frey, K.P.H.; Vasuki, N. C. and Trask, P.

NEW COMPREHENSIVE STUDIES ON SUDDEN ENLARGEMENTS

Recent studies on sudden enlargements have confirmed by classifying types of flow that large ratios of length over width are significant in flow redistribution and performance. The study of starting vortices clarified physical aspects. The applicability of the potential vortex motion theory to flow control by cusp diffusers was reconsidered. Finally, it was experimentally shown that the various concepts used for sudden enlargements are not contradictory. They merely present different phases of the flow with a transition between the two phases. This was clearly demonstrated in the study of some special cusp devices.

The significance of transition flow phenomena from one kind of stability to another one, suggested more studies of the previous and related kind. In addition, the interest in making use of the theory of potential vortex motion, and of comparing results with those of the impulse momentum theorem, let to this paper on "New Comprehensive Studies on Sudden Enlargements".

G-019

Gaylord, W.; Gottron, R. N.

A TEMPERATURE CONTROL SYSTEM USING FLUERIC COMPONENTS

See Author, Gottron, R. N.

G-020

Gee, M. T.; Bradshaw, P.

TURBULENT WALL JETS WITH AND WITHOUT AN EXTERNAL STREAM

Reports and Memoranda No. 3252*, June, 1960

See Author Bradshaw, P.

*Previously issued as A.R.C.   22,008

G-021

Gehring, A. J. Jr.; Jacoby, M.; Reader, T. D. (Sperry-Rand Corp)

PURE FLUID COMPUTER

U. S. Patent No. 3, 190,554 dated June 22, 1965, filed June 19, 1963

This invention relates to a pure fluid, digital Computer and in particular to a novel internally programmed computer.

G-022

Gelin, P.

ARRANGEMENT FOR CONTROLLING THE FLOW OF A FLUID, A MEANS OF AN AUXILIARY FLOW

U.S. Patent No. 2,914, 916, December 1, 1959

This invention provides an arrangement for controlling the flow of a fluid by means of a flow of auxiliary fluid at a suitable pressure, this arrangement being capable of use either to vary by means of gaseous constriction the cross-section of the passage available for the main flow in the tube through which the flow passes, or to cause the main flow to deviate momentarily from its normal direction. The arrangement includes at least two injectors or nozzles from which the auxiliary fluid may be discharged into the tube at two different parts of a transverse section, through orifices the length of which, at the transverse section, is a fraction of the periphery of the tube.

B-74

G-023

Gibson, D. M.; Mellor, G. L.

EQUILIBRIUM TURBULENT BOUNDARY LAYERS

See Author Mellor, G. L.

G-024

Glaettli, H. H. (IBM Zürich Research Lab-Switzerland)

BASIC PROPERTIES OF FLUID MECHANIC ELEMENTS

Paper given at the First Conference on Fluid Logic and Amplification, Sponsored by the British Hydromechanics Research Association and the College of Aeron. Cranfield, England. September 9-10, 1965

G-025

Glaettli, H. H. (IBM - Zürich Research Lab. - Switzerland)

CIRCUITS USING FLUID DYNAMIC COMPONENTS

Paper given at the First Conference on Fluid Logic and Amplification sponsored by the British Hydromechanics Research Association and College of Aeron. Cranfield, England. September 9-10, 1965

G-026

Glaettli, H. H. (IBM)

FLUID DEVICES FOR COMPUTORS

U. S. Patent No. 3,114, 390, December 17, 1963

This invention relates to fluid apparatus and more particularly to an arrangement of a plurality of fluid controlling cells wherein each cell has a main stream, controllable by a control imput means, which selectively deflects the stream to flow into an output means and each cell is arranged so that a stabilizing influence is exerted upon the stream when flowing into the output means. In the field of fluid operated computer devices, this unit may be utilized for fast switching.

G-027

Glaettli, H. H. (IBM)

FLUID LOGICAL DEVICES

U.S. Patent No. 3,122, 313 dated February 25, 1964, filed May 11, 1961

This invention relates to fluid operated logical devices and more particularly to a versatile fluid operated logical device capable of performing a great variety of logical operations.

G-028

Glaettli, H. H.; Müller, H. R.; Zingg, R. H.

REMARKS ON THE LIMITATIONS OF PURE FLUID ELEMENTS

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-28, 1964

The first part is concerned with refinements of the limitation of pure fluid elements. On the one hand, basic effects in connection with the aspect ratio (turbulent reattachment, laminar attachment) are discussed: on the other hand, the influence of deviations from ideal geometries is demonstrated. These deviations comprise oblique walls and surface roughness factors that can no longer be neglected.

The second part comprises additions to graphs and formulas published earlier. They show in a quantitative way the width of the gap to be overcome by improved or new manufacturing techniques. Consequences of requirements such as given output pressure or given response time are demonstrated. Last but not least, a new figure of merit in connection with bandwidth considerations is proposed. This figure of merit is expected to be always smaller than one. It can be applied to elements with or without intrinsic positive or negative feedback. The effect of feedback, implicitly present in various pure fluid elements, on the response time when switching in different direction occurs, is finally demonstrated by a film.

G-029

Glaetti, H. H.

RÉUNION DE PRINTEMPS DE LA SOCIÉTÉ SUISSE DE PHYSIQUE A LUCERNE LE 5 MAI 1962

Journal of Applied Mathmatics and Physics (Journal de Mathématiques et de Physique appliquées), ZAMP, Vol. XIII, 1962, Pages 500-502

Hydro-und aercdynamische Verstärker, die abgesehen von der Flüssigkeit keine beweglichen oder deformierbaren Teile aufweisen, sind das Resultat neuerer Entwicklungen. Bisher sind drei solche Verstärkertypen bekannt: Freistrahl-, Wirbelkammer-und Grenzschicht-Verstärker. Wahrend die ersten beiden der analytischen Behandlung eher zugänglich sind als der dritte, scheint letzterer die besten Aussichten auf Anwendungen zu bieten.

G-030

Glaetti, H. H.

SIMILARITY RELATIONS & CHARACTERIZATION OF PURE FLUID ELEMENTS

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965

The purpose of this paper is to demonstrate a simple elementary manner to arrive at a few diminsionless constants, which, together with the representative size and the fluid properties (viscosity, density) give an effective description of fluid elements.

G-031

Gluskin, R. S.; Jacoby, M.; Reader, T. D. (Sperry Rand Corp. Univac Division)

A FLUID-LOGIC DIGITAL COMPUTER

COMPUTER DESIGN, June 1965, Page 26

The use of fluids (both liquids and gases) for the transmission and amplification of power has been common for over a century. This power has been controlled by valves, pistons, and other mechanical parts. Within the past decade considerable attention has been given both in this country and in Russia, to the use of fluids for control and logic functions, and until recently these systems also employed mechanical moving parts. In 1960 the Diamond Ordnance Fuze Laboratory of the U. S. Army announced a fluid amplifier with no moving parts--a discovery which seems likely to revolutionize the whole field of fluid logic and control.

G-032

Gluskin, R. S.; Jacoby, N; Reader, T. D. (Sperry Rand)

THE UNIVAC FLUID COMPUTER

Proceedings of the 1965 Joint Automatic Control Conference (6) held at Rensselaer Polytechnic Institute, Troy, New York, June 22-25, 1965. A65-28816

The UNIVAC Fluid Computer has amply demonstrated that a pure fluid general-purpose digital computer is indeed feasible. The question remains: Is such a computer desirable? There are many areas in which fluid logic cannot hope to compete with electronic logic simply because of the speed limitation inherent in fluid systems even if the utmost advantage is taken of parallel and polymorphic operation. Conversely, however, there are areas involving extreme environments such as very high radiation levels or very high temperatures, where present-day electronics cannot hope to compete with fluids, and here fluid logic may supply the only means of solving many pressing military and space science problems.

UNIVAC is a registered trademark of the Sperry Rand Corporation

G-033

Goldschmied, F. R.; Letham, D. L. (Sperry, Utah)

ANALYTICAL INVESTIGATION OF FLUID AMPLIFIER DYNAMIC CHARACTERISTICS

Sperry Rand Company, Utah - Report - Vol. I, December 30, 1964

This report covers four separate investigations bearing on the subject of analytical and experimental investigation of fluid amplifier dynamic characteristics. The first investigation is a theoretical effort aimed at the numerical solution of the time-dependent incompressible two-dimensional Navier-Stokes equations for the case of a viscous jet in an arbitrary flow field. The second investigation is an experimental effort aimed at establishing realist dynamic test standards for NOR and NAND fluid digital amplifiers. The third investigation is a theoretical analysis of a passive circuit consisting of a volume-terminated transmission tube, for a viscous compressible fluid. The fourth investigation is an experimental study of the feasibility of a Fluid Control Subsystem for a hybrid thrust-vector-control servosystem.

G-034

Goldschmied, F. R.; Fox, H. L.

BASIC REQUIREMENTS FOR AN ANALYTICAL APPROACH TO PURE FLUID CONTROL SYSTEMS

See Author Fox, H. L.

G-035

Goldschmied, F. R.

DYNAMIC SIMILARITY ANALYSIS OF COMPRESSIBLE VISCOUS FLUID PIPE FLOW

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965

This paper discusses the necessity of employing dimensional analysis when relying on the empirical approach in fluid problems and in particular to present the Stokes-Reynolds Similarity Laws for dynamic flow circuit.

G-036

Goldschmied, F. R; Lechner, T. J. (Johnson Service Company)

FEASIBILITY STUDY OF A FLUIDIC CONTROL SUBSYSTEM

ASME Paper 65WA/AVT-10 presented at the Winter Annual Meeting Chicago, November 7-11, 1965

A Fluidic control subsystem is described and analyzed, to operate at low pressure within a hybrid servosystem comprising conventional servovalve and actuator operating at very high pressures. Complete steady-state data are given for the sybsystem and also dynamic response data for the operational amplifier. The fluidic control subsystem operates at 2.3 pressure ratio and comprises an electric command transducer (0.2 to 0.8 volts), a fluid position feedback transducer, either linear (0 to 3 in.) or angular (0 to 75 deg) and an operational summing amplifier with push-pull output (0 to 1.7 pressure ratio). The interface between the low-pressure fluidic subsystem and the high pressure servovalve and actuator is given by fluid bellows which accept the amplifier's pressure output and deliver the force input to the servovalve.

G-037

Goldschmied, F. R.; Letham, D. L.; Fox, H. L.

FLUID AMPLIFIERS DYNAMIC CHARACTERISTICS, Vol. II

   See Author Fox, H. L.

G-038

Goldschmied, F. R. (Sperry Rand Corp.)

PROPOSED TEST STANDARDS FOR NOR AND NAND FLUID DIGITAL AMPLIFIERS WITH SOME
PRELIMINARY EXPERIMENTAL RESULTS

Proceedings of the 1965 Joint Automatic Control Conference, 6th, Rensselaer
Polytechnic Institute, Troy, New York, June 22-25, 1965, IAA-A65-28781

   Dynamic testing standards are proposed for pure fluid NOR and NAND digital
amplifiers. Testing circuits and procedures, data reduction and presentation
are proposed and discussed in detail, together with data scaling laws. Two
active amplifier levels are proposed both upstream and downstream of the test
component to bring out any dynamic feedback and acoustic effects. Some
preliminary data have been obtained using fifteen axisymmetric focussed-jet
NOR amplifiers, invented and developed by the Author; a fan-in of three and
a fan-out of three has been used, at a supply pressure of 5 psig and a pulse
frequency of 15 cps.

   The NOR amplifier (with a 0.010" jet width) was found to have a switching
time of 0.5 milli-second when tested in the proposed manner. These results
demonstrate that the proposed test methods are both practical and useful,
warranting serious consideration by the workers in the pure fluid technology field.

G-039

Goodson, R. E. and Oldenburger, Rufus

SIMPLIFICATION OF HYDRAULIC LINE DYNAMICS BY USE OF INFINITE PRODUCTS

ASME Paper No. 62--WA-55, Transactions of the ASME Journal of Basic Engineering

   In many hydraulic control and other systems the effect of fluid carrying lines
is an important factor in system dynamics. Following electrical transmission
line technique a hydraulic line between two cross sections is characterized by
a four-terminal network with pressure and flow the interacting variables. Use
of this four-terminal network in a variety of system problems leads to transfer
functions relating pairs of variables in the system, where these transfer functions
are transcendental. These transfer functions cause serious mathematical difficulties
when employed for the computation of system transients.

G-040

Goto, J. M.; Dockery, R. J.; Katz, Silas

EXPERIMENTS IN ANALOG COMPUTATION WITH FLUIDS

See Author Katz, Silas

G-041

Gotoh, K. (Kyoto University, Japan)

THE DAMPING OF THE LARGE WAVE-NUMBER DISTURBANCES IN A FREE BOUNDARY LAYER FLOW

Physical Society of Japan Journal, Vol. 20, January 1965, Pages 164-169

Calculation of the amplification factor$_{ci}$ of small disturbances in a free boundary layer flow of a viscous, imcompressible fluid for large values of the wavenumber α . The author finds that there exist two asymptotic branches, both of which represent the rapidly damping disturbances. This result confirms the existence of the inviscid damping which had been pointed out in a previous paper

G-042

Gottron, R. N.; Gaylord, W. (Harry Diamond Labs)

A TEMPERATURE CONTROL SYSTEM USING FLUERIC COMPONENTS

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. III, October, 1965

An all pneumatic system developed recently at the Harry Diamond Laboratories exhibits a pressure or flow output that is a function of the temperature of the gas in the sensing system.

Laboratory tests from 21° to $120^{\circ}C$ showed the d-c output level to be proportional to frequency over this range. The frequency, in turn, is proportional to the gas temperature. The differential output pressure change was about 150 millibars.

G-043

Gottron, R. N. (Harry Diamond Labs)

ACOUSTIC CONTROL OF PNEUMATIC DIGITAL AMPLIFIERS

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-28, 1964

The effect of audio-frequency acoustic waves on a pneumatic digital unit is considered. Experimental evidence is presented to show that digital units can be switched with less acoustic power than pneumatic power. The use of mixing to reduce high frequency information to a usable range is discussed and experimental evidence is presented.

G-044

Gottron, R. N.; Weinger, S. D. (Harry Diamond Lab.)

FLUID AMPLIFIERS: PARAMETERS AFFECTING THE NOISE IN NO-MOVING-PARTS FLUID DEVICES

TR-1283 (Contract DA-1PO14501A33B), DDC Report No. AD-618057, April 15, 1963

The noise in fluid amplifiers is discussed. Previous work on free circular jets has been applied to confined two-dimensional jets to predict possible noise sources. Possible noise reduction techniques are considered, both in the interaction area of fluid amplifiers and in the design of receivers. Recommendations for future work and an extensive reference list are included.

G-045

Gottron, R. N. (Harry Diamond Labs)

NOISE REDUCTION BY JET-EDGE RESONATOR COUPLING

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-28, 1964

It is found that noise of only relatively low amplitude is present in pneumatic amplifiers when the jet-edge frequency and the resonant-cavity frequency are approximately the same. When these two oscillations are out of tune, broadband audible noise is present. The amplitude of the noise in several successive velocity regions is shown by a series of photographs of a spectrum analyser. Proportional amplifiers can be designed to effectively reduce the noise for chosen input parameters. Experiments indicate a reduction in pressure of the noise up to 80% for certain velocity ranges. The design criteria of splitter distance and cavity length are investigated and related to the design of proportional amplifiers.

G-046

Graber, S. D.; Richards, E. F. (Martin/Orlando)

TRANSITION TO TURBULENCE AND WALL ATTACHMENT OF MINIATURE JETS

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. IV, October, 1965

See Author Richards, E. F.

G-047

Gray, J. L. (Sperry Rand Corp.)

FLUID PULSE GENERATOR

U. S. Patent No. 3,202,180 dated August 24, 1965, filed February 8, 1963

This invention relates to an analog-to-digital converter using fluid means and particularly to a novel fluid pulse generator.

G-048

Gray, K. E.; Coleman, D. D.

THEORETICAL & EXPERIMENTAL INVESTIGATION OF THE COMPRESSIBLE FREE MIXING OF TWO DISSIMILAR GASES.

See Author·Coleman, D. D.

G-049

Gray, W. E.; Stern, Hans (General Electric Company)

FLUID AMPLIFIERS: CAPABILITIES AND APPLICATIONS

Reprinted from CONTROL ENGINEERING, February, 1964

Fluid amplifiers are analog or digital amplifiers using a liquid or a gas as the working medium - with no moving parts. The authors describe the various types of fluid amplifiers, outline their characteristics, and compare them with other analog and digital control devices. Several application studies that show significant advantages - both economic and technical - to be gained from the use of fluid amplifiers are described also.

G-050

Greber, I; Koerper, P. E.; Taft, C. K.

FLUID VORTEX AMPLIFIER OPTIMIZATION

Proceedings of the HDL Fluid Amplification Symposium, Vol. II, October, 1965

A vortex amplifier is designed to obtain maximum flow shutoff capability. Empirical relations are established which describe the miximum flow conditions of the amplifier. They are used to predict the shutoff capability as a function of the amplifier outlet and inlet areas, and consequently to design for maximum shutoff. The optimized amplifier produced a flow shutoff of less than 9 per cent maximum flow and was a bistable, hysteretic device.

A non-hysteretic amplifier was designed by modifying the hysteretic amplifier. Its shutoff capability is less than 14 per cent of maximum flow.

G-051

Greenblott, B. J. (IBM)

FLUID CONTROLLED DEVICE

U. S. Patent No. 3,148,691 dated September 15, 1964, filed June 7, 1962

This invention relates to devices for controlling switching of a fluid power stream selectively into a plurality of outlet passages. The invention relates more particularly to devices of the so-called "fluid amplifier" type which employ fluid pressure actuated flexible, expandable, or displaceable members to control switching of the power stream without commingling of the control pressure fluid with that of the stream.

G-052

Griep, D. J.

FLUID FLYWHEEL ATTITUDE CONTROL SYSTEMS STUDY

DDC Report AD-606316 (Aerospace Corp. Los Angeles, California), for Contract AF04695269, August, 1964

A single-axis attitude control system using a fluid flywheel as the torque-producting element is analyzed. The control laws that are either analyzed or derived are: (1) Proportional control, (2) Minimum orientation time control, and (3) Minimum electrical power consumption control. Pontryagin's maximum principle was used to derive the latter two control laws. Experimental laboratory data are presented for the proportional control system. The smooth, low-velocity performance obtained using a fluid flywheel is demonstrated.

G-053

Griffin, William S.

BISTABLE FLUID JET AMPLIFIER WITH LOW SENSITIVITY TO RECEIVER REVERSE FLOW

Technical Reprint - from Third Fluid Amplification Symposium, October 26-28, 1965
NASA TMX -52120

A selected bistable fluid jet amplifier is presented which exhibits low
receiver-interaction region coupling and which also has reasonable receiver power
recoveries and control signal pressures and flows. The receivers are specifically
designed to handle load reverse flow such as might be delivered by a piston. If
the control signal pressure is increased approximately 50 per cent above that
necessary to switch the power jet into an unblocked receiver, the jet may be
switched into a receiver pressurized at 40 per cent supply.

G-054

Griffith, William A.; Byrd, Joe L.

SYSTEM AND COMPONENT CONSIDERATIONS FOR AN ALL PNEUMATIC MISSILE
ATTITUDE CONTROL SYSTEM

AIAA Guidance and Control Conference, August 12-14, 1963, Paper 63-330 Massachusetts
Institute of Technology, Cambridge, Massachusetts NASA A63-21593

See Author Byrd, Joe L.

G-055

Gustofson, R. D. (Purdue University)

A NEW SERVOVALVE CONCEPT - THE BALL VALVE

Proceedings of the Society of Automotive Engineers, Aerospace Fluid Power
Systems and Equipment Conference, Los Angeles, California, 1AA-A65-28067, May 18-20,
1965, Paper No. 650318

The new type of fluid device described in this paper is closely analogous to
a vacuum tube cathode follower amplifier. It provides an output pressure equal
to an input control pressure, but with a high input impedance and low output impedance
providing a power gain. A string of balls moving in response to pressures acting
on the ball surfaces provides the basic valve action. Because of its structure
and the use of balls as the control elements, this device is relatively easy to
manufacture, does not require a lubricating fluid and can be operated at high
temperatures.

H-020

Hahn, E. J.; Hind, E. C.

THE TRANSFER FUNCTION OF THE PNEUMATIC CAPACITANCE

See Author Hind, E. C.

H-021

Hahn, G. J.; Shinn, J. N.; Underwood, F. A. (GE Company)

PROCEDURE FOR OBTAINING FLUID AMPLIFIER RELIABILITY DATA

NASA Report prepared by the General Electric Company for Contract NAS-8-5408, November, 1965

See Author Shinn, J. N.

H-022

Hall, J. F.; Taplin, L. B.

PROGRESS OF THE U.S. AIR FORCE RESEARCH ANJ TECHNOLOGY DIVISION - FDL PROGRAM "SYNTHESIS OF PURE FLUID FLIGHT CONTROL SYSTEM."

Paper given at the AlAAl/ON Guidance & Control Conference, August 16-18, 1965, Minneapolis, Minnesota

H-023

Halleen, R. M

A LITERATURE REVIEW ON SUBSONIC FREE TURBULENT SHEAR FLOW

DDC Report AD-606758 (Stanford University for Contract AF49 638 1278), April, 1964

Solutions, for both two-dimensional flow and three-dimensional axially symmetric flow, are reviewed for the three major free turbulent shear flow topics: The turbulent shear layer, the turbulent wake, and the turbulent jet. Several models for the turbulent shear stress were used in some of these solutions. These solutions are compiled in consistent nomenclature and compared. For each of the three topics, the defining partial differential equations for the particular turbulent shear stress models and geometric conditions are given, followed by the transformation of the variables utilized in obtaining a solvable differential equation. Finally, the solution is presented. Experimental mean velocity profile data for each condition are correlated and reduced to a curve using the least squares curve fitting technique. A table of coordinates for each curve is given.

H-024

Hallum, C. E; Fix, J. W.; Kaufman, W. F.

A PURE-PNEUMATIC REGULATOR

See Author Kaufman, W. F.

H-025

Hanson, A; Larson, R.; Krause, F.; Dahm, W.

HEAT TRANSFER BELOW REATTACHING TURBULENT FLOWS

See Author Krause, F.

H-026

Harry Diamond Laboratories

FLUID AMPLIFICATION SYMPOSIUM, Vol. I

Proceedings of the Fluid Amplification Symposium (third) Vol. I, October, 1965

Theoretical study of a Convergent Nozzle and Free Jet Flow; Experimental
tudy of a Convergent Nozzle and Free Jet Flow; Pressure Recovery characteristics
of Compressible Two-Dimensional Free Jet Flows; The Flow of Turbulent Incompressible
Two-Dimensional Jets over Ventilated Cavities; Flow stability for Two-Dimensional
Cusp Devices; New Comprehensive Studies on Sudden Enlargements ; Spreading Rates
of Compressible Two-Dimensional Reattaching Jets Upstream of Reattachment;
Calculation of the Separation of a Jet Attached to a Convex Wall; Analysis of the
Steady-Flow Pneumatic Resistance of Parallel Capillaries; Similarily Relations and
characterization of Pure Fluid Elements; Dynamic Similarily Analysis of Compressible
Viscous Fluid Pipe Flow; a Definition of the Mechanical Potential Necessary to a
Fluid Circuit Theory; On the Future of Dynamic Analysis of Fluid Systems; An
Approach to Broad Band Fluid Amplification at Acoustic Frequencies; Predicting
Closed Loop Stability of Fluid Amplifiers from Frequency. Response Measurements;
On the Dynamical Characteristics of Fluid Amplifiers and Elements; Impedance
Matching in Bistable and Proportional Fluid Amplifiers Through the Use of a Vortex
Vent.

H-027

Harry Diamond Laboratories

FLUID AMPLIFICATION SYMPOSIUM, Vol. II

Proceedings of the Third Fluid Amplification - Symposium, Vol. II, October, 1965

A temperature - Insensitive Oscillator and a Pressure-Controlled Oscillator; Development of a Pressure Controlled Oscillator for FM Systems; Fluid Dynamic Effects of Liquids in Elastic Tubes; Transient Response of a Fluid Line With and Without Bleeds; Experiment and Theory of Acoustically Controlled Fluid Switches; Some Influences of Turbulence on the Noise of Proportional Fluid Amplifiers; Effect of Receiver Design on Amplifier Performance and Jet Profile of a Proportional Fluid Amplifier; Steady and Transient Behavior of a Bistable Amplifier With a Matching Vortex. Performance Characteristics of Vortex Amplifiers; Fluid Vortex Amplifier Optimization; Characteristics of a Vortex Device and the Vortex Breakdown Phenomenon; Experimental Profiles of Velocity Components and Radial Pressure Distribution in a Vortex Contained in a Short Cylindrical Chamber; A Theoretical and Experimental Investigation of the Vortex-Sink Angular Rate Sensor; Flow studies in a Vortex Rate Sensor; Photoviscous Flow Visualization in Fluid State Devices; Turbulence Amplifier for Integrated Two-Dimensional Fabrication; Digital Data Handling Speeds with Pure Fluid (Pneumatic circuits).

H-028

Harry Diamond Laboratories

FLUID AMPLIFICATION SYMPOSIUM, VOL. III

Proceedings of the 3rd Fluid Amplification Symposium, Vol. III, October, 1965

Experimental Study of a Proportional Fluid Amplifier; Bistable Fluid Jet Amplifier with Low Sensitivity to Receiver Reverse Flow; Development of a Pure Fluid Norgate and a Norlogic Binary to Decimal Converter; A Pneumatic Tape-Reader; Fluid State Hybrid Control Systems; A Fluid State Digital to Analog Converter; A Digital-Proportional Fluid Amplifier for a Missile Control System. A Development Report on a Fluid Amplifier Attitude Control Valve System; Application of Fluerics to Missile Attitude Control; A Second Generation of Fluid System Applications A Fluid State Absolute Pressure Ratio; A Temperature Control System using Flueric Components; Fluid Timer Development; The Use of a Fluid Amplifier in an Intermittent Stream Release Valve for High Attitude Research; An Evaluation of a Fluid Amplifier Face Mask Respirator; A Fluid Operated Diesel Locomotive Transition Control Unit; Area Experience in Moderate Volume Fabrication of Pure Fluid Devices.

H-029

Harry Diamond Laboratories

FLUID AMPLIFICATION SYMPOSIUM, Vol. IV

Proceedings of the 3rd Fluid Amplification Symposium, Vo. IV, October, 1965

The Analysis of Submerged Jet Flow Fields by a Numerical Field Computation Method; Schlieren Observations of the Effect of Sound Injected into the Power Nozzle of a Helium-Into-Air Jet; The Effect of Sound on a Re-Attaching Jet at Low Reynolds Numbers; Transition to Turbulence and Wall Attachments of Miniature Jets; An Experimental Study of the Static Interaction of an Axisymmetrical Fluid Jet and a Single Receiver-Diffuser; Dynamic Interaction of a Fluid Jet and a Receiver Load System; Transient Theory of Switching in a Bistable Valve; Flueric Pressure Regulation Using a Resistance Set Point; A Flueric Induction and Gate; Mechanically Entrained Fluidic Oscillator; Steady Flow in a Pure Fluid Valve TVC System; Experimental Study of Fluid Controlled Valves; Experimental Investigation of the Performance Characteristics of a Flow-Instability Sensing Device.

H-030

Harry Diamond Laboratories

FLUID AMPLIFICATION SYMPOSIUM - VOLUME I, May 26, 27, 28, 1964

ASTIA Report AD-601499

The Viscous Dissipation of Energy in Free Turbulent Flows Occurring in Fluid Amplifier Operation; Some Aspects of Curved Turbulent Mixing Important in Fluid Amplifiers and Fluid Logic Devices; Investigations of Interacting Underexpanded Jet Flows; Spreading Rates of Compressible Two-Dimensional Reattaching Jets; The Interaction of Oblique Shocks and Expansion Waves With a Jet Boundary Mixing Zone; Separated Flow in Curved Channels; Jet Interaction Noise; Deflection and Relative Flow of Three Interacting Jets; Noise Reduction by Jetedge and Resonator Coupling; A Hydrodynamic Study of the Free Jet Class of Fluid-Jet Amplifiers; Wall Reattachment Device With Pulsed Control Flow; Remarks on the Limitations of Pure Fluid Elements; On the Stability of Fluid Systems; Low-Pass Filters for Pneumatic Amplifiers; Basic Requirements for an Analytical Approach to Pure Fluid Control Systems; The Response of a Bistable Fluid Amplifier to a Step Input; The Effect of Geometric Changes Upon the Switching Point in a Model Bi-stable Fluid Amplifier; A High Gain Proportional Fluid State Flow Amplifier.

H-031

Harry Diamond Laboratories

PROCEEDINGS OF THE FLUID AMPLIFICATION SYMPOSIUM, MAY, 1964, VOLUME II

ASTIA Report AD601500

The Impact Modulator; Some Properties and Applications of Direct and Transverse
Impact Modulators; Control Characteristics of Vortex Valves; Experimental Study
of a Proportional Vortex Fluid Amplifier; Characteristics of a Vortex Fluid
Throttle; Characteristics of Counter-Vortex Oscillators; Application Techniques
for Proportional Pure Fluid Amplifiers; Static Design of Pneumatic Logic Circuits;
Application of Pure Fluid Logic to On-Off Control Systems; Theoretical Analysis
of Fluid Amplifier Design; The Turbulence Amplifier in Control Systems; Multiple-
Ball Pneumatic Amplifiers; The Staging of Pressure Proportional Amplifiers to
Provide Stable, Medium Gain, Dual Control, Single Output Pure Fluid Systems;
Development of a Proportional Fluid Amplifier for Multi-Stage Operation; Experiments
in Analog Computation With Fluids; A Fluid Encoding System; Feasibility Study of a
Fluid Amplifier Steam Turbine Speed Control; Applications of Pure Fluid Techniques
to a Speed Control; A Pure Fluid Hydrofoil Control System; A Status Report on the
Experimental Development of a Hot Gas Valve; Development of Two Pure Fluid Timers.

H-032

Harry Diamond Laboratories

FLUID AMPLIFICATION SYMPOSIUM - VOLUME III

ASTIA Report AD601501

Proceedings of the Fluid Amplification Symposium, Volume III, May 26,27,28, 1964

Transient Behavior of Bistable Fluid Elements; A Sonic Oscillator; Interconnectio
of Fluid Amplification Elements; Staging of Closed Proportional Fluid Amplifiers;
Angular Velocity Regulation With a Fluid Interaction System, Fluid Amplification
Technology: A Bibliography of Direct Contributions.

H-033

Harry Diamond Laboratories

PROCEEDINGS OF THE FLUID AMPLIFICATION SYMPOSIUM, MAY, 1964, (2nd) Volume IV

ASTIA Report AD-605289, May, 1964

Attachment of a Jet to a Curved Wall, Separated Flow in Curved Channels With Secondary Injection, Application of Pure Logic to On-Off Control Systems, a Fluid Encoding System, Thrust Vector Control Using a Bleed Offreinjection Device, Supersonic Fluid Amplification With Various Expansion Ratio Nozzles, High-Speed Schlieren Cinematography, Four Fluid Amplifier Controlled Medical Devices, Fluid Units of the Ball Valve Type and their Application to the Control of a Machine Tool.

H-034

Harvey, D. W.; McRae, R. P.

EXPERIMENTAL STUDY OF FLUID CONTROLLED VALVES

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. IV, October, 1965

This report presents the results of a cold flow test program in which the flow in a supersonic bistable valve was investigated. Two different final valve configurations were developed that worked well under identical conditions, but the flow in one was quite different from the other.

Shadowgraphs of the flow are presented for most stages as the designs evolved. The effects of variation of valve design parameters are shown. Flow visualization and static pressure results are given for the two final valve configurations.

Some implications of these results are discussed, and future work is outlined.

H-035

Harvey, D. W.; McRae, R.P. (Douglas Aircraft Co.)

STEADY FLOW IN A PURE FLUID VALVE TVC SYSTEM

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. IV, October, 1965

A discussion of the application of bistable fluid-controlled valves to thrust vector control systems is presented, considering steady flow only. It is shown from pressure considerations that supersonic flow must exist in the valve body. From the effect of injectant total pressure on side force, it is also shown that the losses involved in decelerating this flow before injection may improve system performance.

H-036

Harvey, D. W. (Douglas Aircraft Company)

TRANSIENT THEORY OF SWITCHING IN A BISTABLE VALVE

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. IV, October, 1965

The basic equations are presented for one-dimensional unsteady flow of the control fluid in a bistable valve during switching. The effect of the induced pressure gradient is included, and a method is indicated for including friction. Solution of these equations by a modification of the method of characteristics is outlined, for the case of small control fluid bubble slope (so that the main stream can be assumed isentropic) and supersonic main stream velocity. It is shown how this solution may predict switching times.

H-037

Hausmann, G. F. (United Aircraft Company)

DIRECTIONAL CONTROL MEANS FOR ROCKETS OR THE LIKE

U. S. Patent No. 3,143,856 dated August 11, 1964, filed June 8, 1961

This invention relates to a bistable fluid operated valve and nozzle arrangement usable for rocket steering or the like. It is the general object of this invention to improve the thrust efficiency of at least one nozzle in a valve and nozzle arrangement of the type mentioned.

H-038

Hausmann, G. F. (United Aircraft Company)

FLUID VALVE

U. S. Patent No. 3,016,063 dated January 9, 1962, filed July 5, 1960

This invention relates to fluid valves and more particularly to deflective-type fluid valves whereby a flow of low energy fluid is used to divert a high energy stream from one direction to another with no moving parts. Such valves have particular application to pure pneumatic computer elements and control devices, which must be capable of operation in extreme environments of temperature, vibration, and nuclear radiation.

H-039

Havee, R. M.

FLUID FLOW CONTROL DEVICE

U. S. Patent No. 3,194,253, dated July 13, 1965, filed June 21, 1962

This invention relates to a novel fluid flow control arrangement which has no moving parts, and which may be utilized to establish and maintain variable flow paths for a fluid stream. More particularly, the invention relates to a novel fluid flow control system for dividing a fluid supply stream into two constituent streams, one of the constituent streams always flowing through a principal exhaust conduit and the other constituent stream selectively flowing through one of a plurity of branch exhaust conduits.

H-040

Hawes, P; Katz, S.; Winston, E. T.

THE RESPONSE OF A BISTABLE FLUID AMPLIFIER TO A STEP INPUT

See Author Katz, S.

H-041

Hayes, W. F.; Kwok, C.

IMPEDANCE MATCHING IN BISTABLE AND PROPORTIONAL FLUID AMPLIFIERS THROUGH THE USE OF A VORTEX VENT

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965

This paper discusses a vent configuration called the Latched Vortex Vent, which can be applied to both proportional & digital fluid amplifiers. This configuration attains impedance matching over a wide range of load conditions, from zero load up to and including large negative loads (i.e. reverse flow into the amplifier). Appreciable pressure recovery capabilities can be maintained while compression pulses propagated back into the amplifier interaction region are largely attenuated.

H-042

Heidmann, Marcus F. ;   Foster, Hampton H.

EFFECT OF IMPINGEMENT ANGLE ON DROP-SIZE DISTRIBUTION AND SPRAY PATTERN OF TWO
IMPINGING WATER JETS

Technical Note D-872 (NASA), Lewis Research Center, Cleveland, Ohio

     See Author, Hampton, H.

H-043

Heidmann, M. F.; Priem, R. J.

PROPELLANT VAPORIZATION AS A DESIGN CRITERION FOR ROCKET-ENGINE COMBUSTION
CHAMBERS

NASA - TR 67 - 1959

H-044

Heidmann, Marcus F.; Foster, Hampton H.

SPATIAL CHARACTERISTICS OF WATER SPRAY FORMED BY TWO IMPINGING JETS AT SEVERAL
JET VELOCITIES IN QUIESCENT AIR

NASA Technical Note D-301, Lewis Research Center, Cleveland, Ohio

     See Author Hampton, H.

H-045

Hellbaum, R. F.

FLOW STUDIES IN A VORTEX RATE SENSOR

Proceedings of the HDL Fluid Amplification Symposium, Vol. II, October, 1965

     With the promising future of fluid state technology, a large number of
highly sensitive pure fluid transducers will be coupled with fluid amplifiers
to produce complete pure fluid control systems. One which is of importance to
control systems is the angular rate sensor.

     A research program was initiated at the Langley Research Center to determine
vortex rate sensor flow patterns. One objective was the determination of the effects
of various geometrical design parameters on the flow patterns so that improvements
could be made in the design of vortex chambers as well as output pickups.

H-046

Hemond, Conrad, J., Jr.

THE TRANSMISSION OF SOUND IN A MOVING FLUID

DDC Report AD601526 (Hartford University; Connecticut Research Institute for contract NONR 430100 NR165 802, Report No. 2)

Developing a measuring technique to determine the performance of acoustic elements in moving streams of water was accomplished to at least a first order of magnitude. The system developed indicates, as illustrated by tne data presented in the report, that a signal can be introduced at one end of a simulated piping system and that its output can be analyzed to demonstrate the type of element present in tne system as well as its acoustic performance both under flow and no-flow conditions. Training undergraduate mechanical and electrical engineers in the problems of acoustics as associated with moving fluids is also being accomplished.

H-047

Hemond, Conrad, J., Jr.

THE TRANSMISSION OF SOUND IN A MOVING FLUID

DDC Report AD604123 (Hartford University, Connecticut. Research Institute) Report No. 3 August, 1964

The report is concerned directly with relating the problem of system noise (turbulence) to one important goal of the project; that is, to impart any desired discrete frequency signal into a moving fluid, to detect and measure this signal, and to determine what effect a mechanical device placed in the channel has on the imput signal.

H-048

Heskestad, Gunnar

TWO TURBULENT SHEAR FLOWS

DDC Report AD605595 (John Hopkins University Baltimore, Maryland for contract AF49 638 248) June, 1963

Results from hot-wire measurements in a plane turbulent jet and a radial turbulent jet are reported. The plane jet was found to be approximately self-preserving sufficiently far downstream, where measurements of the intermittency and data for calculating the energy balance of the turbulent motion were made. Measurements

H-048 (Continued)

Heskestad, Gunnar

TWO TURBULENT SHEAR FLOWS

were also made of the Reynolds Number effect on the centerline development of the
turbulent intensity and the flatness factor of the velocity derivative at a fixed
downstream centerline location. The radial jet was observed not to attain the degree
of self-preservation noted for the plane jet in the range of the measurements.
The mean velocity profiles were quite similar, but the means-quare Turbulent
velocity profiles were similar only away from the Centerline, and the lateral
intermittency distributions were highly dissimilar. Data for the energy balance
was obtained at a convenient downstream location.

H-049

Hind, E. C.; Hahn, E. J. (University of South Wales, Kensington Australia)

THE TRANSFER FUNCTION OF THE PNEUMATIC CAPACITANCE

ASME Paper 65-WA/AUT-18 - presented at the Winter Annual Meeting, Chicago, Illinois,
November 7-11, 1965'

The generalized transfer function, associated with the pneumatic capacitance of
a fixed mass of gas in a rigid walled container, is developed taking into account
the heat transfer during compression and expansion. The transfer function so
obtained is relatively complex but may be simplified by assuming negligible heat
loss to the atmosphere or by the fulfillment of specified condition equations.
The transfer functions are verified experimentally and an attempt is made to correlate
the system time constant with the relevant system variables.

H-050

Hodge, J; Hutchinson, J. G. (Maxam Power Ltd. U. K.)

TURBULENCE AMPLIFIERS - PRINCIPLES AND APPLICATIONS

Paper given at the First Conference on Fluid Logic and Amplification sponsored
by the British Hydromechanics Research Association and College of Aeron. Cranfield,
England, September 9-10, 1965

H-051

Holman, J. P.; Soehngen, E. E.

EXPERIMENTAL STUDIES ON THE INTERACTION OF STRONG SOUND FIELDS WITH FREE CONVECTION BOUNDARY LAYERS

Report 277 presented at the Boundary Layer Research Meeting of the AGARD Fluid Dynamics Panel held from 25-29 April, 1960, in London, England.

This report presents a summary of experimental results, obtained under an Air Force research program, on unsteady-state heat -transfer phenomena, initiated and executed by the authors. The reported data have been obtained by three independent studies, each dealing with a different type of sound environment:

1. Standing sound wave fields, studied by Professor J. Kaye and Dr. R. Fand (Ref. 77) of the Massachusetts Institute of Technology, under contract No. AF 33(616) - 3157;
2. Constant pressure or diffuse sound fields, studied by T. P. Mott-Smith (Ref. 98);
3. Traveling sound wave fields, studied by L. Sprott (Ref. 97)

The work under phases 2 and 3 was conducted by the Aeronautical Research Laboratory of the Air Force Research Division in cooperation with the Air Force Institute of Technology. It was made possible by the cooperation of the Bio-Acoustics Branch of the Aero/Space Medical Laboratory of W. A. D. D., whose sound facilities were used for conducting the tests. The cooperation of Dr. von Gierke, Lt. Durand, and other personnel of the Aero/Space Medical Laboratories is gratefully acknowledged.

H-052

Holmes, A. B.; Foxwell, J. E. (Harry Diamond Labs)

A DEVELOPMENT REPORT ON A FLUID AMPLIFIER ATTITUDE CONTROL VALVE SYSTEM

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. III, October, 1965

A digital hot gas fluid amplifier attitude control valve system has been built at HDL. The control system consists of a fluid amplifier reaction-jet valve, four solenoid actuators, a solid-propellant hot gas generator, and a regulated control air supply. The control hardware has been packaged in a Test Instrumentation Missile (TIM) and is scheduled for flight testing at the Redstone Arsenal Missile Test Range in May, 1965. This report describes the evaluation, design, and specifications of the hybrid fluid valving system that is to be employed in this flight test.

H-053

Holmes, A. B.; Sieracki, L. M.; Campagnuolo, C. J; Foxwell, J. E.

APPLICATION OF FLUERICS TO MISSILE ATTITUDE CONTROL

    See Author Campagnuolo, C. J.

H-054

Holmes, A. B.; Foxwell, J. E., Jr. (Harry Diamond Labs)

SUPERSONIC FLUID AMPLIFICATION WITH VARIOUS EXPANSION RATIO NOZZLES

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. IV, May 26-28, 1964

    The design and performance of high pressure supersonic fluid amplifier
devices is discussed. A single amplifier design is evaluated using conical power
nozzles with expansion ratios of 5, 10, 15, 20, and 25. All experiments were
performed using air as the flowing medium.

    The effect of expansion ratio on the input pressure level is determined, and
an analysis for predicting the operating pressure level for various expansion
ratio nozzles is presented. The predominant effects of pressure loading and
friction loading are presented. Flow switching at input pressures in excess of
1000 psia with sea-level atmospheric air control signals is discussed. Output
thrust measurements are noted and estimates of the kinetic energy losses due
to the ducting of high-velocity gases are given.

H-055

Hope-Gill, C. D.

AN EXPERIMENTAL INVESTIGATION INTO THE SHAPE OF THRUST-AUGMENTING SURFACES IN
CONJUNCTION WITH COANDA DEFLECTED JET SHEETS (Part I)

DDC Report AD-611759 (Institute for Aerospace Studies University of Toronto, Ontario)
Contract DA TC44177G1, December, 1964

    It is known that by means of additional surfaces, the thrust of a jet or
jet sheet can be enhanced (thrust augmentation). This especially applies to
coandadeflected jet sheets because of the inherent stronger entrainment into
curved flow surfaces. The flow from A TWO-Dimensional subsonic nozzle was
deflected by quadrants. A composite thrust-augmenting surface was added, and
the effect of its shape on thrust augmentation was studied at various nozzle
pressure ratios and radii of the quadrants. This investigation yielded a maximum
thrust augmentation of 1.21 for several optimum configurations, which was governed
primarily by the relative magnitude and direction of the momentum of the secondary
(entrained) flow in relation to the primary (nozzle) flow momentum.

H-056

Horton, B. M.

CONTROL, AMPLIFICATION AND FLUIDS

DDC Report AD-612129 (Harry Diamond Lab), June, 1964

Military applications of fluid amplification currently being investigated include: Logic and timing circuits for ordnance; rocket thrust vectoring, missile attitude control; automatic piloting of aircraft; hydrofoil control; jet engine control; heart massaging; and artifical respiration. It is a little early to say just how far this new medium will go in each of these fields, but the inherent advantages of simplicity and ruggedness give strong impetus to the work. The term 'simplicity' above does not necessarily refer to the state of understanding necessary to cause an all-fluid system to work properly. In fact, each device having significantly different characteristics usually points out the need for additional fundamental knowledge of fluid flow. The resulting practical impetus to research activity is aided by the realization that all-fluid systems can 'think' in the manner of electronic systems (though not nearly as fast) and that full exploitation of this capacity requires better analysis and synthesis of fluid flow phenomena in order to permit more orderly design of fluid systems.

H-057

Horton, B. M

FLUID-OPERATED SYSTEM

U. S. Patent No. 3,122,165, February 25, 1964

This invention relates to fluid amplifiers employing no moving parts in which amplification depends upon magnitude of deflection of a stream of fluid resulting from controlled fluid pressure gradient provided transversely of the direction of flow of the fluid stream. The apparatus is provided with at least two outlet or fluid recovery apertures or passages, facing the power stream, and the recovery aperatures or passages are arranged such that when the power stream is undeflected by the control stream, all of the fluid of the power stream is directed to a first of the outlet passages.

H-058

Horton, B. M; Bowles, R. E.

FLUID OSCILLATOR

U. S. Patent No. 3,185,166 dated May 25, 1965, filed April 8, 1960

This invention relates to fluid systems in general and more specifically to fluid oscillators capable of producing periodically recurring changes in fluid flow.

H-059

Horton, B. M

FLUID SERVO SYSTEM

U. S. Patent No. 3,111,291, November 19, 1963

    This invention relates to a fluid-operated system which utilizes the flow of a fluid so that the system performs functions which are analogous to functions now being performed by electronic components and systems. It is the object of this invention to provide a fluid-operated system which requires no moving parts. Amplification depends upon magnitude of deflection of a stream of fluid resulting from controlled fluid pressure gradient provided transversely of the direction of flow of the fluid stream.

H-060

Horton, B. M.

FLUID SYSTEM FOR AIRCRAFT CONTROL

U. S. Patent No. 3,137,464 dated June 16, 1964, filed September 19, 1960

    This invention relates to a fluid-operated system which utilizes the flow of a fluid so that the system performs functions which are analogous to functions now being performed by electronic components and systems, and relates more particularly to such a system employed for aircraft orientation control.

H-061

Horton, H. B.

SYSTEM AND APPARATUS FOR PRODUCING, MAINTAINING AND CONTROLLING LAMINAR FLUID STREAM FLOW

U. S. Patent No. 3,182,674, dated May 11, 1965, filed July 24, 1961

    This invention relates to a system and apparatus for effectively producing, maintaining and controlling laminar flow of a fluid stream.

H-062

Howie Corporation

FLUID LOGIC FUNDAMENTALS AND THE TURBULENCE AMPLIFIER

Howie Corporation, Norristown, Pennsylvania, May 1, 1965.

This report covers two areas; first, a basic exposition of fluid logic fundamentals and the characteristics of a basic component, the turbulence amplifier, and second, the design techniques used in building complex arithmetic and industrial computing and control equipment. The Pneumatic Logic Laboratory enables the reader to actually build and observe the operation of complex logic systems using fluid logic techniques. It can therefore be considered an educational or experimental device for either fluid logic systems or computational and control device study.

H-063

Howland, G. R.

FLUID STATE AMPLIFIER AND COMPENSATION FOR THE MODEL NV - B1 GIMBAL ACTUATOR

NASA CR-62522 (Bendix Corporation. Final Report BPAD-864-15651R on Contract NAS-8-5407), April, 1965

This report covers the analysis, design, and test effort performed from 29 June 1964 to 29 March 1965 on a pure fluid amplifier, servovalve and compensation network for use with the model NV-B1 Pneumatic Actuator for thrust vector control of the J-2 Rocket Engine.

The amplifier was designed as a breadboard device to demonstrate the feasibility of replacing the electronic components and the spool valve of the actuator by pure fluid components of the vortex design. The results of the program indicated that such a concept is feasible and gave reasonably good dynamic performance. A follow-on development program is described to optimize the amplifier system design and performance.

H-064

Howland, G. R.

PERFORMANCE CHARACTERISTICS OF VORTEX AMPLIFIERS

The purpose of this paper is to present recent developments of a different version of fluid amplification, namely, the vortex amplifier. Although the concept of the vortex amplifier is not new, the development of this device has not received the attention which potential applications warrant. It is hoped that this paper will help to draw attention to the vortex amplifier addition to the family of fluid interaction devices.

H-065

Hrubecky, Henry F.; Pearce, Larry N. (Tulane University)

FLOW FIELD CHARACTERISTICS IN A MODEL BI-STABLE FLUID AMPLIFIER

An experimental investigation as to the nature of the flow field encountered during the intersection and consequent mixing of two different two-dimensional jets under bounded wall conditions was conducted. The jets interacted in a flow geometry, i.e., mixing chamber and diffuser, similar to the one encountered in bi-stable fluid amplifiers. To this end, a model fluid amplifier system was designed and constructed incorporating considerable flexibility in flow conditions and in amplifier geometry. The experimental system is pictured in Figs. 1a and 1b. With the above model system it was possible to vary the following: 1. The primary and control jet intersection angle, 2. Setback, 3. Position proximity of the control jet with respect to the primary jet, 4. The width of the mixing region, 5. The diffuser angle, 6. The primary and control jet pressures and flow rates, 7. Diffuser exit pressures. Recently the effect of diffuser wall length has been investigated, as well as, the effect of primary and control nozzle aspect ratios. These latter results are not reported in this paper.

The present investigation, in addition to the overall effect upon jet switching of each of the above flow and geometric parameters, was concerned with the nature of the general flow characteristics found in the amplifier, i.e., the static pressure field and velocity field during and after the mixing of the primary and control jets.

H-066

Hrubecky, Henry F.; Pearce, Larry N.

THE EFFECTS OF GEOMETRIC CHANGES UPON THE SWITCHING POINT IN A MODEL BI-STABLE FLUID AMPLIFIER

The present study was concerned with the effect of varying the principal geometric parameters upon the switching point in a model bi-stable fluid amplifier. The ability for considerable geometric variation was built into a single model system, and of the same nature as described in a previous paper presented at the Symposium. Consequently, the system as conceived and designed was capable of giving a maximum of geometric flexibility which enabled a systematic evaluation of the effect of geometry on amplifier operation.

For the model amplifier under consideration, it was possible to vary the following geometric and flow parameters: (1) the primary and control jet pressures and flow rates, (2) the primary and control jet intersection angle, (3) the setback, (4) the position proximity of the control jet with respect to the primary jet, (5) the width of the mixing region, (6) the diffuser angle, (7) the flow divider wedge position, (8) the flow divider wedge angle, (9) the diffuser length, (10) the primary and control jet aspect ratios, and (11) the diffuser exit pressures or amplifier loads.

The present experiments were conducted under no-load conditions (item 11 in the above) as well as without the flow divider wedge in position, no variations in the diffuser length, or variations in primary and control jet aspect ratios. Experiments involving the above variables are at present underway, and in some instances have been completed.

H-067

Humphrey, Ronald L.; Manion, Francis M.

LOW-PASS FILTERS FOR PNEUMATIC AMPLIFIERS

This paper presents some experimental results of tests performed on preliminary low-pass filter designs for pneumatic systems. The results indicate which of several methods of filtering seem most promising for application to pure fluid elements. Fluid systems, as their counterparts in electronics, are subject to noise problems. High gain pressure amplifiers have acoustic noise problems by virtue of their design. To overcome these noise problems it would be most desirable to eliminate the noise source but in these elements the source of the noise is the geometrical configuration which gives high linear gain. Therefore,

H-067 (continued)

Humphrey, Ronald L; Manion, Francis M.

LOW-PASS FILTERS FOR PNEUMATIC AMPLIFIERS

any effort to reduce noise would affect a desirable gain characteristic. It appears expedient to design filters to eliminate most of the undesirable noise while passing the amplifier signal. This is possible because a great deal of the objectionable noise occurs at a frequency far greater than the useful range of the amplifier. This paper deals with the experimentation of some low-pass filter designs.

One of the cardinal rules in design of the low-pass filter is not to attenuate the amplifier signal. Therefore, a great effort was made in these tests to assure that the filter did not attenuate the DC level. The filters tested were either from theoretical adaptions of classical designs, or were merely based on experience.

H-068

Hurrell, H. G.

ANALYSIS OF INJECTION-VELOCITY EFFECTS ON ROCKET MOTOR DYNAMICS AND STABILITY

NASA - TR-43 - 1959

H-069

Hurvitz, H.

BOUNDED JET FLUID AMPLIFIERS

U. S. Patent No. 3,004,547 dated October 17, 1961, filed July 22, 1960

This invention relates to fluid amplifier and more particularly to fluid amplifiers utilizing confined or bounded power jets in distinction to the free, unbounded or uncomfined power jets heretofore known.

H-070

Hutchinson, J. G; Hodge, J.

TURBULENCE AMPLIFIERS - PRINCIPLES & APPLICATIONS

See Author Hodge, J.

I-002

Inglis, M. E.; Reeves, D; Airey, L. (National Gas Turbine Est. U. K.)

THE FLUID OSCILLATOR AS A TEMPERATURE SENSOR

Paper given at the First Conference on Fluid Logic and Amplification, September 9-10, 1965, sponsored by the British Hydromechanics Research Association and the College of Aeron. Cranfield, England.

I-003

Inoue, K.; Togino, K.

UNIVERSAL FLUID LOGIC ELEMENT

Control Engineering, May, 1965

        See Author Togino, K.

I-004

Iseman, J.; Katz, A.

ANGULAR SPEED CONTROL WITH A BISTABLE FLUID AMPLIFIER

Product Engineering - July, 1963, Page 133

I-005

Iseman, J. M. (Harry Diamond Labs.)

ANGULAR VELOCITY REGULATION WITH A FLUID INTERACTION SYSTEM

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. III, May 26-28, 1964

        A two-position control system using no moving parts to regulate the angular velocity of a turbine has been constructed and evaluated. The experimental model uses the two outputs of a bistable fluid amplifier as correction jets, one tending to drive (speed up) a turbine, one tending to load (slow down) the turbine. The amplifier is appropriately switched by the outputs of a pneumatic angular velocity sensor, so that the turbine speed is varied continuously between speeds 2 per cent faster and 2 per cent slower than a nominal, desired speed. The switching characteristics of the bistable fluid amplifier, and design and operation of the sensor and transmission lines are described and analyzed.

I-006

Iwata, H.; Nelson, D. J.

APPLICATION OF PURE FLUID LOGIC TO ON-OFF CONTROL SYSTEMS

See Author Nelson, D. J.

J-004

Jackomis, William N. and Zumwalt, Glen W.

AERODYNAMIC THROAT NOZZLE FOR THRUST MAGNITUDE CONTROL OF SOLID FUEL ROCKETS

ARS Journal, Volume 32, Number 12, December, 1962, Pages 1934-1936

The aerodynamic throat is a device that has often been considered in fluid
flow systems, but it seems to have been overlooked in the one application for
which it is especially well suited. This is for thrust magnitude control of
solid fuel rockets. In other applications, the aerodynamically variable throat
(AVT) nozzle reduces the flow rate by its introduction of secondary flow of fluid
at or near the throat. This per cent reduction is of the order of twice the
per cent of secondary-to-primary mass flow.

J-005

Jacoby, M.; Reader, T. D.; Gluskin, R. S.

A FLUID-LOGIC DIGITAL COMPUTER

        See Gluskin, R. S.

J-006

Jacoby, M.; Gehring, A. J. Jr.; Reader, T. D. (Sperry Rand)

PURE FLUID COMPUTER

U. S. Patent No. 3,190,554 dated June 22, 1965, filed June 19, 1963

        See Author Gehring, A. J., Jr.

J-007

Jacoby, M.; Reader, T. D.; Gluskin, R. S.

THE UNIVAC FLUID COMPUTER

        See Author Gluskin, R. S.

J-008

Janak, P. H.

EXPERIMENTAL AND THEORETICAL ASPECTS OF A FLUID AMPLIFIER

1AA Report A64-13496, also AIAA Student Journal, Vol. I, December, 1963

Preliminary theoretical and experimental investigation of the various parameters affecting the amplification and the linearity of application of a fluid amplifier in view of its potential application. The fluid amplifier is considered as a low-pressure measuring device, which takes the fluid being considered directly into use. It is shown that although linear amplification curves are obtained in some cases, no trends involving linearity are established. It is thought that eventually linear amplification curves from which pressures may be measured, will be made.

J-009

Janow, Carl

SOME ASPECTS OF FLUID SYSTEMS FOR FUTURE SPACE MISSIONS

Paper presented at the Society of Automotive Engineers Committee A-6 meeting - Boston, Massachusetts, September 17, 1964

Within NASA studies and developments using fluid system concepts have been encouraged and examined for the past few years. The activities relating specifically to control, such as computers, systems concepts, components, etc. are being pursued at the Marshall Space Flight Center and the Langley and Lewis Research Centers for some time. NASA is interested in the development of a complete line of digital fluid components-sensors, actuators, controllers and read-out devices. The immediate attention needs to be directed to components, both digital and analog. Many of these components are beginning to emerge, and many more are needed.

J-010

Jeglum, N. L. (Sheffield Corp.)

FLUID STATE DEVICES USED FOR PROPORTIONAL AMPLIFICATION AND FLIP-FLOP SWITCHING

ASME - Publication 65MD-27 - Presented at the American Society of Mechanical Engineers, Design Engineers Conference and Show, May 17-20, 1965

Fluid-State Devices have been developed in many forms. Their use is applicable to the engineering and design of metal-removal equipment and related inspection equipment. The fluid state industry is in its infancy and expected to grow significantly in the next five years. Industrial applications have been completed and have been in operation for several months.

J-011

Joesting, F. D (Honeywell, Inc.)

FLUID AMPLIFIER CONTROL SYSTEM

U. S. Patent No. 3,171,421 dated March 2, 1965, filed December 7, 1961

　　This invention is directed to a fluid amplifier diverting system and more particularly is directed to a two-stage amplifier of exceedingly compact construction that is capable of being switched between two positions by merely opening or closing a pilot valve of a thermostatic type.

J-012

Joesting, F. D. (Honeywell Inc.)

FLUID FLOW CONTROL DEVICE

U. S. Patent No. 3,159,208 dated December 1, 1964, filed March 23, 1961

　　This invention is directed to a flow control device for use in a temperature control or an air conditioning system and more specifically is directed to a fluid switching unit that is capable of directing flow through a heat exchange coil or bypassing the flow around the coil. In this device there are no moving parts and the entire switching function is accomplished by a unique configuration of fluid amplifier.

J-013

Joesting, F. D.

TWO-STAGE FLUID OSCILLATOR

U. S. Patent 3,098,504, July 23, 1963

　　The present invention is directed to a fluid operated device that utilizes a recently developed fluid amplifier principle. More specifically, the present invention is directed to a fluid amplifier type of oscillator that utilizes two stages of fluid control and wherein both stages are arranged to occupy the same layer within the device. In most fluid amplifier type devices that utilize more than a single stage, the stages are cascaded in separate layers and these layers are then interconnected by appropriate pipes. The present two-stage fluid amplifier type oscillator is arranged in a generally concentric arrangement thereby allowing a single layer for two amplifier stages.

J-014

Johnson, E. G. (Honeywell, Inc.)

FLUID AMPLIFIER APPARATUS

U. S. Patent No. 3,171,915, dated March 2, 1965, filed May 15, 1962

This invention comprises a control means having a plurity of conditions; control signals are operable to change the condition of the control means. The invention comprises a fluid amplifier having a movable means which perform a control or switching function in response to fluid flow control signals.

J-015

Johnston, Richard Paul

DYNAMIC STUDIES OF TURBULENT REATTACHMENT FLUID AMPLIFIERS

Submitted to the Graduate Faculty of the Schools of Engineering and Mines in partial fulfillment of the requirements for the degree of Master of Science in Mechanical Engineering, University of Pittsburgh, 1963

The dynamic switching behavior of a turbulent reattachment fluid amplifier, as measured by the Strouhal number, is relatively unaffected by changes in the main-jet Reynolds number. This is true when the main jet is fully turbulent. Control flow rate is found to be a very important factor in the dynamic behavior of the amplifier. A hypothesis relating the control flow to the separation time of the main jet from a wall is made and experimentally verified. The values of the vortex bubble volume enlargement at separation are determined and found to vary little with the main-jet Reynolds number for a given model. The volume change does vary with model geometry, however. Determination of the two physical constants of the fluid amplifier and main jet, the control fluid entrainment rate and the vortex bubble volume change.

J-016

Jones, D. R.; Dexter, E. M. (Bowles Engineering Co.)

BIAS DEVICE FOR PURE FLUID AMPLIFIER

U. S. Patent No. 3,209,775 dated October 5, 1965, filed December 7, 1962

See Author Dexter, E. M.

J-017

Jones, J. B.; Foss, John F.

A STUDY OF INCOMPRESSIBLE BOUNDED TURBULENT JETS

See Author Foss, J. F.

J-018

Jones, N. S.; Foster, K.

AN EXAMINATION OF THE EFFECT OF GEOMETRY ON THE CHARACTERISTICS OF A TURBULENT
RE-ATTACHMENT DEVICE

See Author Foster, K.

J-019

Joyce, James; Mon, George; Straub, Henry; Woodward, Kenneth

FOUR FLUID AMPLIFIER CONTROLLED MEDICAL DEVICES

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. IV, May 26-28, 1964

See Author Woodward, Kenneth

K-026

Kadosch, M. (Bertin & Co. - La Garenne - Colombes, France)

ATTACHMENT OF A JET TO A CURVED WALL

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. IV, May 26-28, 1964

In the applications to propulsion, as in those to fluid amplifiers, the phenomenon of attachment to a wall is first felt as an obstacle, if it is not controlled or controllable. The most often cited means of controlling in fluid amplifiers consists in bringing fluid between the wall and the jet to impede the low pressures created in the confined zones. Several processes have been used in the application to propulsion, in order to impede the thrust losses in normal operation and with a view to a better control of the deviation in reverse operation.

K-027

Kadosch, Marcel

CALCULATION OF THE SEPARATION OF A JET ATTACHED TO A CONVEX WALL

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965

The separation of a jet of width w along a wall of constant radius of curvature r is calculated using the formulae of turbulent boundary layers with positive pressure gradient. An illustrative example shows that separation occurs at a distance $w \, (r/r_o)^{5/3}$ increasing with r when r is greater than a critical radius r_o which depends slightly upon Reynolds number.

K-028

Kadosch, Marcel; Bertin, Jean; Maunoury,   François

FLUID FLOW CONTROL DEVICE FOR JET PROPULSION NOZZLES

K-029

Kadosch, Marcel; Le Foce, Jean; Maunoury, François

FLUID FLOW CONTROL DEVICE FOR JET PROPULSION NOZZLES

French Patent Spec.   745,630, December, 1951

A device for varying the effective area of the propelling nozzle of a jet propulsion engine, comprising fluid injecting means opening into said propelling nozzle and extending through a wall of said propelling nozzle over at least a portion of a peripheral zone thereof. Characteristics of device - 1) fluid injecting means is located at or near the outlet end of the propelling nozzle, 2) fluid injecting means extends substantially around the whole periphery of the propelling nozzle.

K-030

Kadosch, M; Pavlin, C. (Société Bertin & Cie, France)

MECHANICAL CHARACTERISTICS OF A PURE FLUID RESPIRATOR WITH CURVED WALLS

Paper given at the First Conference on Fluid Logic and Amplification, September 9-10, 1965 sponsored by the British Hydromechanics Association and College of Aeron. Cranfield, England.

K-031

Kadosch, M; Bertin, J.

PRINCIPLES & APPLICATIONS OF AXIAL & DIRECTIONAL CONSTRICTION

See Author Bertin, J.

K-032

Kallevig, John A.

EFFECT OF RECEIVER DESIGN ON AMPLIFIER PERFORMANCE AND JET PROFILE OF A
PROPORTIONAL FLUID AMPLIFIER

Experimental data taken using a proportional amplifier with a one-half
inch power nozzle is presented to show the effects of receiver geometry on the
upstream velocity and total pressure profiles and amplifier performance. The
work has two major sections. The first part covers the extreme case where the
outlets are completely blocked and all of the flow exits through the vents. The
second part consists of a survey of the pressure distribution and velocities
within the amplifier having no vents, i.e., all of the flow exiting through the
receiver. These data were taken using four different receivers and bellmouth
configurations.

K-033

Kantola, R. A.; Ziemba, R. T.

FLUID TIMER FOR ORDNANCE APPLICATIONS (GE Co. - Missile & Armament Department,
Report 65APB4-1) For Contract DA19020AM0213A

Program goals are to develop a miniaturized pneumatic timer and demonstrate
the functional feasibility. Fluid amplifiers are used throughout the timer,
thus providing a no-moving-parts device with inherent ruggedness and reliability.
The timing function is provided by a binary counter that is driven by an oscillator.
Variable time durations are achieved by presetting the counter. This phase of
the program is divided into two parts. One part is devoted to the oscillator
which provides the basic time reference. The large oscillator (0.04 inch nozzle
size) was improved so that an accuracy of $= 0.5\%$ was achieved for a 5:1 range
of supply pressures. The other part is devoted to miniaturization of the counter
circuit. The preliminary design work on the counter was completed. Scaled down
circuits (0.010 inch nozzle size) were tested to determine steady state stability
and reset characteristics. Results thus far are satisfactory.

K-034

Kantola, R. A.; Ziemba, R.; Avery, H. W.

FLUID TIMER FOR ORDNANCE APPLICATIONS

        See Avery, H. W.

K-035

v. Kármán, T.; Biot, M. A.

MATHEMATICAL METHODS IN ENGINEERING

McGraw-Hill Book Company, Inc., 1940

K-036

Katz, A.; Iseman, J.

ANGULAR SPEED CONTROL WITH A BISTABLE FLUID AMPLIFIER

Product Engineering - July, 1963, Page 133

K-037

Katz, Silas; Goto, J. M.; Dockery, R. J.

EXPERIMENTS IN ANALOG COMPUTATION WITH FLUIDS

Proceedings of the HDL 2nd Fluid Amplifier Symposium, Vol. II, May 26-28, 1964

        A study is made of the use of passive and active fluid components without
mechanical moving parts to perform analog computations. The active fluid
component is the proportional fluid amplifier with feedback. Multiplication
by a constant greater than unity and integration are demonstrated. The errors
in computation are considered with a view toward designing better components.

K-038

Katz, S.; Roffman, G. (Harry Diamond Labs)

FLUERIC OPERATION ON PRESSURE SIGNALS

ASME Paper No. 65-WA/PID-2 presented at the Winter Annual Meeting, Chicago, Illinois
November 7-11, 1965

A three-stage, jet-deflection-type, proportional fluid amplifier with feedback
is used to demonstrate some mathematical and control operations. The operations
performed on pressure signals are summing, scaling, proportional plus integral,
and proportional plus derivative. The test results show that these devices are
already suitable for applications where high accuracy is not required.

K-039

Katz, Silas; Roffman, Gary L.

PREDICTING CLOSED LOOP STABILITY OF FLUID AMPLIFIERS FROM FREQUENCY RESPONSE
MEASUREMENTS

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. I, October 26-28, 1965
        See Author Roffman, Gary L.

K-040

Katz, Silas; Dockery, R. J.

STAGING OF PROPORTIONAL AND BI-STABLE FLUID AMPLIFIERS

Harry Diamond Lab Report TR-1165   ASTIA Report No. AD-421613, August 30, 1963

The generalized performance characteristics are examined in detail for
both proportional and bi-stable (digital) fluid amplifiers with no moving parts.
An approach leading to the solution of fluid systems design problems is given.
Equations describing the pressure and flow variations are developed. Typical
performance curves are drawn showing performance trends with several variables
manipulated. Experimental curves are presented confirming the theoritical approach.
A typical proportional unit, with principal dimensions, is shown with its
characteristics curves.

K-041

Katz, Silas; Winston, E. T; Hawes, P.

THE RESPONSE OF A BISTABLE FLUID AMPLIFIER TO A STEP INPUT

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-28, 1964

Switching times of two configurations of bistable fluid elements were measured at various power and control jet pressures. The units differed mainly in the ratio of control nozzle width, for element 1 this was 1.0 for element 2 it was 0.67. The measured switching times ranged for element 1 from 13 to 44 μs and for element 2 from 100 to 150 μs. The longer switching times for element 2 are believed to be due to the relatively smaller control orifice.

The observed switching appears to be due to momentum forces. When these are not predominant, the switching times are expected to be appreciably longer.

K-042

Kaufman, W. F; Hallum, C. E; Fix, J. W.

A PURE-PNEUMATIC REGULATOR

SAE 1965 Aerospace Fluid Power Systems & Equipment Conference, May 21, 1965

A pure-pneumatic regulator, with no moving parts, which controls downstream pressure is described in this paper. Regulator function is a basic fluid dynamic principle. The device has a continuous flow and requires a near constant upstream pressure. The pure-pneumatic regulator provides rapid response and accurate pressure control even with small ullage volumes and full on-off control. The regulator is reliable and can withstand severe environmental effects of high acceleration and vibration.

The principle of operation, theoretical performance and measured experimental performance are presented. The initial application of the pure-pneumatic regulator is discussed to illustrate a typical method of utilization. Reliability, response and function in severe environments are gained at the expense of stored energy. The trade-off factors of primary importance are noted.

K-043

Kelleher, M. D.; Yang, Kwang -TSU

ON HYDRODYNAMIC STABILITY OF TWO-DIMENSIONAL UNSTEADY INCOMPRESSIBLE LAMINAR - BOUNDARY LAYERS

DDC Report AD-600102 - Notre Dame University Report for Contract NONR - 1623-11).

See Author Yang, Kwang, TSU.

K-044

Kelly, R. E.

PARAMETRIC AMPLIFICATION OF SURFACE AND INTERNAL WAVES

DDC Report AD 605728 (Fluid Dyn. Research Lab., Mass. Inst. of Tech.) for contract AF AFOSR15663, June, 1964

The report concerns the possible amplification of waves in fluids due to fluctuations with time of some parameter which defines in part the natural frequencies of the system. Resonance is most likely to occur when some characteristic frequency is half of the frequency of parametric variation. First, the fluid is taken to be within a container which oscillates in the vertical direction so that the gravitational acceleration, relative to the container, varies with time. Both surface waves, in the case of an interface, and internal waves, in the case of continuous variation of density, are considered. In the latter case, the possible resonant frequencies have an upper bond. For an interface, rotation tends to eliminate the resonance of surface waves but to promote the resonance of inertial waves. For a continuous variation of density, rotation tends to place a lower bond on the possible resonant frequencies. Secondly, two fluids of different densities are taken to flow parallel to each other in an oscillatory manner.

K-045

Kepler, C. E., Olson, R. E. (United Aircraft)

BISTABLE FLUID VALVE

U. S. Patent No. 3,135,291 dated June 2, 1964, filed June 14, 1961

This invention relates to means for providing angularly related fluid jets which may be utilized in exercising directional control over the flight of vehicles such as liquid and solid propellent rockets.

K-046

Keshock, E. G.; Savino, J. M.

EXPERIMENTAL PROFILES OF VELOCITY COMPONENTS & RADICAL PRESSURE DISTRIBUTIONS IN A VORTEX CONTAINED IN A SHORT CYLINDRICAL CHAMBER

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. II, October, 1965

See Author Savino, J. M.

K-047

Keto, J. R. (Harry Diamond Lab.)

TRANSIENT BEHAVIOR OF BISTABLE FLUID ELEMENTS

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. III, May 26-28, 1964

A qualitative study was made of the transient behavior of a bistable fluid element when subjected to a suddenly applied input. The correlation of data obtained from pressure transducers and high-speed schlieren photographs shows that the behavior is governed by reflections of pressure waves within pneumatic lines attached to the element. The splitter location, setback, and power jet pressure ratio have relatively minor effect. An oscillator based upon these findings is discussed.

K-048

Khokhlov, V. A.

HYDRAULIC POWER AMPLIFIERS

DDC Report AD413571 - Translated from Izdated'stvo ak ademii nauk SSSR, Moskva, 1961

In this report, hydroamplifiers will be understood to mean hydraulic devices which cause displacement of sliding valves or other controlling devices of hydraulic actuating mechanisms with simultaneous amplification of the power of the input signal. The adoption of this definition reflects the distinctive feature of the conditions of operation of hydraulic amplifiers, that which distinguishes them from hydraulic actuating mechanisms and other hydraulic devices.

K-049

Kirshner, Joseph M.

A DEFINITION OF THE MECHANICAL POTENTIAL NECESSARY TO A FLUID CIRCUIT THEORY

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965

This paper attempts to define the mechanical potential (the analog of the voltage) for a fluid circuit. From the energy equation, it is shown that for an ideal gas a logical possibility is

$$e = \overline{\frac{v^2}{2} + \int \frac{dp}{\rho}}$$

where v $=$ velocity
    p $=$ pressure
    ρ $=$ density, and the average is taken over the cross-sectional area

K-050

Kirshner, J. M. & Campangnuolo, C. J.

A TEMPERATURE - INSENSITIVE PNEUMATIC OSCILLATOR AND A PRESSURE - CONTROLLED PNEUMATIC OSCILLATOR

Proceedings of the HDL Fluid Amplification Symposium, Vol. II, October, 1965

Theoretical developments and confirmatory experimental results are given for (1) an oscillator insensitive to temperature (over a limited range) and (2) an oscillator with frequency proportional to pressure.

K-051

Kirshner, J. M.

PROGRESS IN FLUID AMPLIFIERS

Machine Design, Vol. 36 No. 29, December 17, 1964, Pages 171-174 176-179

Fluid amplification devices without moving parts are described in which signal
output is larger than input; principles used in passive devices and components with
fluid interaction circuits are discussed and their applications are reviewed. Fluid
amplifier pumps were used for medical aids as heart pumps, respirators, oxygenators,
and heart-massage machines; fluid interaction principle can be applied to reaction-
jet and rocket thrust vectoring and other control devices.

K-052

Kirshner, J. M.   (Harry Diamond Labs)

SOME TOPICS IN FLUID CIRCUIT THEORY

Paper given at the First Conference on Fluid Logic and Amplification sponsored
by the British Hydromechanics Research Association and College of Aeron.
Cranfield, England, September 9-10, 1965

K-053

Klass, Philip J.

FLUID/GAS SYSTEMS CHALLENGING ELECTRONICS

Aviation Week & Space Technology, November 30, 1964, Vol. 81, Pages 36-37-39-41

Virtual monopoly which electronics has enjoyed for two decades in complex
automatic control applications is now being challenged by systems using
moving gases or liquids, which are particularly attractive for some aerospace and
military applications. The new technology, referred to broadly as "fluid systems",
despite the fact that some use air or gas as the working medium, can operate at
elevated temperatures and in a nuclear radiation environment, which pose
severe problems for electronics. In addition, fluid systems are relatively simple
and inexpensive to manufacture, have few if any moving parts and are expected
therefore to be extremely rugged and reliable.

K-054

Klass, Philip J.

FLUID SENSORS OPEN WAY TO MANY SYSTEMS

Aviation Week & Space Technology, Vol. 81, December 7, 1964, Pages 52,53,55, and 59

Development of new fluid-type sensors, capable of measuring angular rate, displacement, velocity acceleration, temperature and pressure, which have direct fluid-type outputs, has opened the way to many systems for aerospace and military uses. Today Honeywell has available a sizable family of fluid sensors capable of measuring almost any parameter of interest in the aerospace-defense field, although not always to the accuracy or sensitivity desired.

K-055

Klein, H. E.

FLUID CONTROL: NEW CHALLENGE TO ELECTRONICS

Supervisory Management (Page 53, September, 1965),

Almost 200 firms are rapidly developing a wide range of projects in the field of fluid technology. Although little hardware is available at the present time, managers in major companies predict that fluid technology will suddenly burst into use in many different industries in the next 2 to 3 years. A few features which have sparked its growth are: 1. Low Cost 2. Special environments 3. Reliability. A Major roadblock is that the actual construction of fluid hardware is still an art rather than a science. This new technology will play an important role in shaping the next generation of equipment in many industries.

K-056

Klein, H. E.

NEW CHALLENGER TO ELECTRONICS

Dun's Review and Modern Industry, June, 1965 Page 48

The new fluid approach is aimed directly at usurping many major electronics markets. Some of the devices already in the testing stage include airplane autopilots, missile guidance systems, industrial process controllers, washing-machine timers and automatic counters on automated production lines. Applications of these new devices include ① Minneapolis Honeywell's fluid system to guide a missile at the Army's Redstone Arsenal ② Howie Corp. has an alarm system monitoring the levels in storage tanks at a chemical plant. ③ Speidel Corp. has installed fluid devices on its automatic production line to count the number of links that go into its flexible watchbands. ④ West Virginia Pulp & Paper is using a fluid control system made by Moore Products Co. to maintain material levels at several stages of its production process.

K-057

Kline, Stephen J.

SOME NEW MECHANISMS AND CONCEPTIONS OF STALL INCLUDING THE BEHAVIOR OF VANED AND
UNVANED DIFFUSERS

Progress Report to the National Advisory Committee for Aeronautics under NACA Contract
NAw-6500, Stanford University, Stanford, California, March 15, 1957

The flow in sub-sonic, plane-walled, two-dimensional diffusers with thin
inlet boundary layers is discussed. It is shown that only some of the results
found in unvaned diffusers and little or none of the results found for vaned
diffusers can be rationalized by arguments based solely on the conventional model
of the flow employing a two-dimensional boundary layer. It is also shown that
some well-known, viscous motions exist in which a steady two-dimensional model of
the flow cannot satisfy the laws of motion for the wall layers.

K-058

Koebile, A.

PNEUMATISCHE VERSTAERKER

Archiv Fuer Technischis Messen, No-336, January 1964, Pages 13-16,

Pneumatic amplifier; Review of principles of operation and design of nozzle
amplifiers, alternating amplifiers, and power amplifiers.

K-059

Koerper, P. E.; Taft, C. K. (Dr.)

FLUID STATE POWER AMPLIFIER DESIGN

Paper presented at the 21st national Conference on Fluid Power, Chicago, Illinois,
October 22, 1965

See Author Taft, C. K. (Dr.)

K-060

Koerper, P. E.; Taft, C. K.; Greber, I.

FLUID VORTEX AMPLIFIER OPTIMIZATION

See Author Greber, I.

K-061

Kolpin, Marc A.

FLOW IN THE MIXING REGION OF A JET

The object of this work is to investigate experimentally the structure of
the early shear layer of high speed jets and its relation to the mechanism of
noise generation. Of special interest was the question of the existence of
periodic fluctuations in the velocity field. A review of the most important
contributions to the problem is given and the problem is formulated mathematically.
It is shown that the knowledge of the two point space-time correlation function
of the fluctuating velocity field is of prime importance in understanding the
sound emission process. The experimental investigation is divided in three parts.

a) Optical observation of the jet flow by means of the shadowgraph technique.

b) Measurement of mean Mach Number and temperature profiles.

c) Survey by means of hot-wire of the u-component of the fluctuating velocity
field.

K-062

Kompass, E. J.

FLUID AMPLIFIERS AS CONTROL COMPONENTS

This report contains articles on the development status of basic devices,
the continuing need for an analytical theory, control components that have been
built from pure fluid devices, and some practical approaches to interconnecting
the elements into systems now. The report concludes with a roundup of some
working applications that have not been described before, just to prove that
fluid amplifiers can be used today.

K-063

Korst, H. H. (Dr.)

DYNAMICS & THERMODYNAMICS OF SEPARATED FLOWS

Dept. of Mechanical & Industrial Engineering, University of Illinois

The study of flow separation by the classical boundary layer theory and
the analysis of wakes by free streamline methods are, by themselves, unsatisfactory.
The dissipative wake flow model subsequently can serve as the basis for delineating
individual components of energy transfer and a thermodynamic systems analysis
allows their subsequent integration into a new and physically perceptive model
for wake flows.

K-064

Krasnoff, E.

THEORY, DESIGN AND TESTS OF FLEXIBLE WALL ACOUSTIC FILTERS.

DDC Report AD-601 103 (Hydronautics, Inc. Laural, Maryland), Contract NOBS 88200,
September, 1963

The theory for flexible wall liquid-filled acoustic filters of two different
types is presented. Equations are derived for the performance prediction of
volume resonators in infinite pipelines and infinite piplines with arbitrary
termination. The effect of noise on filter performance is studied and illustrated.
An experimental determination of performance of a volume resonator filter
indicates good agreement with theory. Equations are presented for the performance
of expansion chamber filters. Their advantages and disadvantages for different
situations are discussed. For the special case of high pressure pipe systems,
it is concluded that volume resonators are more suitable than expansion chamber
filters.

K-065

Krause, F; Dahm, W. (NASA-Huntsville) and Hanson, A; Larson, R. (Litton Systems)

HEAT TRANSFER BELOW REATTACHING TURBULENT FLOWS*

Paper No. (65-825) Presented at the AIAA Aerothermochemistry of Turbulent Flows
Conference held December 13-15, 1965

The effect of turbulent fluctuations on base heating rates has been measured
in a simple model test utilizing a blunt trailing edge in a Mach 3 wind tunnel.
Kestin, et. al., noted that a small increase of turbulence level from 0-3% raises
stagnation point heat transfer on cylinders up to 80%. The plume interaction between
clustered rocket exhausts produces extremely high fluctuations through impingement

K-065 (Continued)

Krause, F;

HEAT TRANSFER BELOW REATTACHING TURBULENT FLOWS*

shock and free shear layer interaction. The fluctuations are then convected and/or radiated backwards towards the vehicle. The base boundary layer has to adjust to turbulence levels exceeding 100%. The associated heat-transfer rates have been measured along with mean velocity, rms velocity, and total temperature and pressure traverses across and along the base boundary layer. The results are discussed in terms of a simple flow model and by a comparison of them with the Hiemenz-Sutera solutions of the Navier Stokes equations.

K-066

Krause, E.; Zakkay, V.

THE RADIAL VARIATION OF THE EDDY VISCOSITY IN COMPRESSIBLE TURBULENT JET FLOWS

DDC Report AD617701 (New York University Report for Contract AF33(615)-1516, May, 1965

K-067

Kuhlenkamp, A. (Prof. Technical University, Braunschweig, Germany)

HYDRAULIC COMPUTER AMPLIFIERS

Paper No. 1.2 presented at the IFAC/IFIP Symposium on Microminiaturization in Automatic Control equipment and In Digital Computers held in Munich, Germany, October 21-23, 1965

Hydraulic torque amplifiers have been developed which can be used in the mechanical computers and directly on the machines which are to be controlled. They have developed three types of such hydraulic motors or actuators ① "Radial Ball" motor (instead of pistons, balls are used. ② motor having an axial cylinder arrangement (also ball motor) ③ Torque motor (actuator).

K-068

Kwok, C.; Hayes, W. F.

IMPEDANCE MATCHING IN BISTABLE & PROPORTIONAL FLUID AMPLIFIERS THROUGH THE USE OF A VORTEX VENT

See Author Hayes, W. F.

L-014

Laitinen, P. O.

FLOW NOISE STUDY OF WATER FLOWING THROUGH PIPES

DDC Report AD-603589 (Navy Electronics Lab, San Diego, California)

Sound pressure fluctuations produced by the turbulent flow of water through 0.494-inch ID pipe of glass, plastic, and brass were measured at controlled flow rates from 0.65 to 9.6 fps, in the absence of extraneous noise. Hydrophone pickups, pipe wall fluctuations, and pressure differential along the boundary layer were recorded, reduced to quantitative graphic form, and were analyzed by harmonic and numerical methods. Broadband magnitudes were related to Reynolds numbers, pressure spectra were derived, and autocorrelations and power spectra were related. Theoretical methods for computing values of water flow noise were compared with quantitive findings, and a method for approximating the magnitude of flow noise for a range of conditions was derived.

L-015

Landau, L. D.; Lifshitz, E. M.

FLUID MECHANICS

Volume 6 of course of theoretical physics, Translated from the Russian by J. B. Sykes and W. H. Reid, Published by Pergamon Press, Addison, Wesley Publishing Co., Reading, Massachusetts, 1959

L-016

Lanin, N. D.

A SMALL SCALE CONTINUOUS ACTION PNEUMATIC COMPUTER AND DELAY BLOCK

DDC Report AD-605509 (Foreign Tech. Div. Air Force Systems Command, Wright Patterson AFB), unedited rough draft Trans of Mono. voprosy Pnevmo - I Gidroavtomatiki, Mosco, 1960

A description is given of continuous action pneumatic computers (PVM-2), developed at the Central Scientific Research Institute of Complex Automation (TSNIIKA) and intended for laboratory investigations of automatic control systems. The movement of the computers is described by ordinary linear differential equations with constant coefficients up to the sixth magnitude inclusive. A description is given of a differentiating link and delay block.

L-017

Lanin, N. D.; Pashintseva, V. I.

METHODS OF CONSTRUCTING PNEUMATIC COMPUTERS OF CONTINUOUS ACTION AND WAYS OF
UTILIZING THEM

DDC Report AD610320 (Translation January 9, 1965), Report dated 1959

In the pneumatic computing devices that are dealt with in this article,
there is used the principle of compensation of force, as a result of which
there are no substantial displacements and there is no slack, friction, etc.

In this article we deal with the problems of the construction of pneumatic
computing devices of continuous action; and there is also described a computing
machine of continuous action which was created on the basis of these elements.

L-018

Lansky, Z. J.

PRACTICAL GUIDES TO PNEUMATIC VALVE APPLICATION

Automation, July, 1965, Page 61

Use of air to power and control production equipment growing. Pacing this
trend is a requirement for higher performance from pneumatic systems. These
factors place increased emphasis on the proper selection, application and
maintenance of pneumatic components of all kinds. In this article a recognized
authority on fluid power provides useful information about pneumatic directional
control valves.

L-019

Larson, R; Krause, F; Dahm, W.; Hanson, A.

HEAT TRANSFER BELOW REATTACHING TURBULENT FLOWS

See Author Krause, F.

L-020

Laverne, M. E.; Boksenbom, A. S.

FREQUENCY RESPONSE OF LINEAR SYSTEMS FROM TRANSIENT DATA

NACA Report 977 - 1950

L-021

Layton, J. P.

SUMMARY TECHNICAL REPORT ON TRANSIENT PRESSURE MEASURING METHODS RESEARCH FOR THE PERIOD March 1, 1961 through December 31, 1962.

NASA Report N63-22047

This summary report of progress from the initiation of research in transient pressure measuring methods as applied to liquid propellant rocket combustion chambers on March 1, 1961 through December 31, 1962 presents a number of elements of current interest in the aerospace propulsion field.

The evaluation and development of flush diaphragm transient pressure transducers for use in current large liquid propellant booster rocket engines is very badly needed and some progress has been made.

L-022

Lechner, T. J.; Goldschmied, F. R.

FEASIBILITY STUDY OF A FLUIDIC CONTROL SUBSYSTEM

See author Goldschmied, F. R.

L-023

Lechner, T. J.; Sorensen, P. H. (Johnson Services)

SOME PROPERTIES AND APPLICATIONS OF DIRECT AND TRANSVERSE IMPACT MODULATORS

Proceedings of the 2nd Fluid Amplification Symposium, Vol. II, May 26-28, 1964

This paper describes some of the properties and applications of unique pure fluid amplifying element called the Impact Modulator. Brief discussion of the operating principles of the two types of modulators (Direct and Transverse) is given, but a more complete description is given in another paper, "The Impact Modulator", of this symposium.

The compatibility characteristics of these devices such as output impedance, transfer curves, etc., are presented. These characteristic curves are used to construct a four stage amplifier with a 12,000 : 1 pressure gain. This amplifier is used to form the forward loop of a pure fluid operational amplifier. The performance characteristics such as gain, linearity, offset etc., of this amplifier are then discussed, and suggestions for improvement are included.

L-024

Lee, P. D ; Ayre, V. H.

AN ANALYSIS OF A TWO AXIS FLUID CONTROL SYSTEM FOR AN ARTILLERY TYPE MISSILE

See Author Ayre, V. H.

L-025

Le Fall, Jean; Maunoury, François; Kadosch, Marcel

FLUID FLOW CONTROL DEVICE FOR JET PROPULSION NOZZLES

See Kadosch, Marcel

L-026

Lefer, Henry

ALL-PNEUMATIC MISSILE SYSTEM ON THE HORIZON

Hydraulics and Pneumatics, June, 1962, Pages 101-11

L-027

Lefer, H.

LETS LOOK AT FLUIDICS PART I - WHERE ARE WE?   WHERE ARE WE GOING?

Hydraulics & Pneumatics, October, 1965, Page 113

    "Fluidics" is the name by which we'll know the new technology that embraces
the interaction of liquid or gas streams and jets. Workers in fluidics have
come from various backgrounds; Fluid Mechanics, Aerodynamics, and Electrical
Engineering. Fluidics today is like an iceberg; information being released is
perhaps a tenth of what is being planned and worked on. Reports of work at the
Raymond N. Auger Co., The Howie Corporation, Giannini Controls and the Franklin
Institute Research Laboratories are given.

L-028

Lemmon, G. V. (Sandia Corp.) Phillips, E. R. (UNIVAC. Division of Sperry Rand)

DEVELOPMENT OF TWO PURE FLUID TIMERS

Proceedings of the 2nd Fluid Amplification Symposium, Vol. II, May 26-28, 1964

Sandia Corporation has many applications for timers to perform various functions. In the past, these components have been designed using what are now proven mechanical and electrical principles, and reliable and satisfactory timing components have been built on each of these and on a combination of both. With the introduction of pure fluid systems, it was felt that the advantages of reliability, cost, accuracy, package size and insensitivity to environment should be investigated. Accordingly, a survey of components was made and two specifications for timers were selected as a basis for the investigation. It was hoped that the development of these timers were selected as a basis for the investigation. It was hoped that the development of these timers would provide a practical test of the applicability of pure fluid systems to the whole family of components of interest to Sandia.

The specifications adopted for this development called for two timers of varying complexity. The first of these was estimated to be producible from present capabilities in the field of pure fluids, and the second was estimated to be of such complexity and size as to be more challenging.

L-029

Leont 'EV, A. I.; Romanenko, P. N.; Oblivin, A. N.

A STUDY OF RESISTANCE AND HEAT EXCHANGE IN THE MOTION OF HEATED AIR IN DIFFUSORS AND MIXERS

DDC Report AD601244 (Aerospace Tech. Div. Library of Congress)

See Author Romanenko, P. N.

L-030

Letham, D. L., Goldschmied, F. R.; Fox, H. L. (Sperry, Utah)

ANALYTICAL INVESTIGATION OF FLUID AMPLIFIER DYNAMIC CHARACTERISTICS

Sperry Rand, Utah Report - Volume II, December 30, 1964

Those aspects of dimensional analysis and similarity which are of most pertinence to fluid circuitry are discussed. The equations of fluid flow through both orifices and circular tubes are given and discussed. The equivalent parameters of passive fluid elements are presented, both steady-state and small signal. The instrumentation of fluids is discussed both for steady-state and time dependent measurements. Typical active devices are described, discussed, and compared. Specific attention is given to the impact Modulator and its use in operational Amplifiers. An equivalent circuit for the impact modulator is found.

L-031

Letham, D. L.; Goldschmied, F. R.

ANALYTICAL INVESTIGATION OF FLUID AMPLIFIER DYNAMIC CHARACTERISTICS

See Author Goldschmied, F. R.

L-032

Lewis, W. J. (Minneapolis Honeywell Co.)

FLUID FLOW FLIGHT CONTROL NEEDS NO ELECTRONICS

Space Aeronautics, April, 1964, Page 126, Vol. 41, Report A64-17194

Description of a new concept for the control and guidance of vehicles in flight, currently being developed by Honeywell and the military services. The concept utilizes the principles of fluid dynamics for sensing, amplifying, shaping, computing and for moment-producing functions. Systems based upon this concept are stated to be unique in the fact that they can perform many of the most important functions of vehicle guidance and control without electronics, and without mechanical wearing surfaces. Demonstrations have been made of the feasibility of applying fluid-flow technology to a practical application.

L-033

Lifshitz, E. M.; Landau, L. D.

FLUID MECHANICS

Volume 6 of course of theoretical Physics Translated from the Russian by J. B. Sykes and W. H. Reid - Published by
Pergamon Press - Addison - Wesley Publishing Co., Reading, Mass. 1959

L-034

Liquornik, D. J.; Curtiss, H. A.

RESEARCH STUDIES IN PROPORTIONAL FLUID STATE CONTROL COMPONENTS, Part 2

    See Author Curtiss, H. A.

L-035

Liquornik, D. J.; Curtiss, H. A.; Feil, O. G.

SEPARATED FLOW IN CURVED CHANNELS

    See Author Curtiss, H. A.

L-036

Liquornik, D. J.; Curtiss, H. A.; Feil, O. G.

SEPARATED FLOWS IN CURVED CHANNELS WITH SECONDARY INJECTIONS

    See Author Curtiss, H. A.

L-037

Lomas, Charles, G.; Metzger, Eric. E.

TURBULENCE AMPLIFIER FOR INTEGRATED TWO-DIMENSIONAL FABRICATOR

    See Author Metzger, Eric, E.

L-038

Lorenz, W. T. (R.I.V. - Germany)

FLUID REGULATOR

U. S. Patent No. 3,198,214 dated August 3, 1965, filed October 30, 1963

This invention relates to a through-flow regulator for liquids or gasses wherein the through-flow quantity is regulated in dependence upon the speed of flow which regulator comprises no movable parts and the regulating behavior and response time of which can be adjusted.

L-039

Lowen, J.; Shearer, J. L. (MIT)

THE ROLE OF NEW DEVELOPMENT IN FLUID POWER CONTROL FOR AEROSPACE SYSTEMS

IAA Report A63-14947 (Paper 593B given at SAE, National Aero and Space Engineering and Manufacturing meeting, Los Angeles, California, October 8-12, 1962, Contract No. AF-33-616-6120 and AF33-657-7535, October, 1962

Discussion of the current research and developments in fluid power control systems with particular reference to aerospace applications. The results of previous developments are briefly considered, and the highlights of recent work on control valves are discussed, including (1) jet amplifiers with no mechanical moving parts (2) pneumatic transmission lines; (3) pneumatic networks and logic circuits; (4) hot-gas rate gyroscopes and servo motors; and (5) complete pneumatic-mechanical control systems. Future research and development for aerospace applications of fluid power control are briefly explored, with emphasis on miniaturization; minimization of moving parts in control systems, problems with dry friction, leakage, conservation of fuel and other forms of energy, gas generation, and treatment and handling of fluids for living space and environmental controls.

L-040

Ludwig, Gary and Brady, W. Gordon

THEORETICAL AND EXPERIMENTAL STUDIES OF IMPINGING UNIFORM JETS

Presented at the IAS 31st Annual Meeting, New York, New York, January 21-23, 1963, IAS Paper No. 63-29

See Author Gordon, W.

L-041

Lugt, H. J.; Schwiderski, E. W.; Uginciu, S.P.

AXISYMMETRIC VISCOUS FLUID MOTIONS AROUND CONICAL SURFACES

DDC Report AD600962 (Naval Weapons Lab), May, 1964

M-047

Maas, Margaret A.

ATMOSPHERIC PORTS CONTROL IN HIGH-PRESSURE VALVE

Design News, September 18, 1963

A valve, developed as a reaction device for missile attitude control, continuously deflects the direction of gas flow from one duct to the other. Operating at frequencies above the response frequency of the missile, the valve controls the flow of hot rocket-exhaust gases.

M-048

Maas, Margaret A.

FLUID AMPLIFIER CYCLE RESPIRATOR

Design News, September 25, 1964, Page 20

A respirator designed by H. H. Straub, Harry Diamond Labs is discussed. Oxygen or a mixture of breathable gases is fed through a flow-control valve into the power nozzle of the amplifier. The stream attaches to one of the receiver walls and flows either to the atmosphere or to the respirator face mask. The fluid amplifier has a high reliability since it has no moving parts. It is easy to operate and inexpensive.

M-049

Maas, Margaret A.

FLUIDIC ELEMENTS, START STOP PROCESS CONTROL PUMP

Design News, September 1, 1965

A small fluid amplifier circuit has been designed with the capability of shutting off a process control pump upon receipt of a 0.15 psig signal from a pneumatic alarm circuit. The output of the circuit is fed to a pneumatic FLIP-FLOP that changes state to stop and start the pump by closing a switch. The fluid system logic consists of two inverter/amplifier elements two OR/NOR elements, a two input FLIP-FLOP and two pneumatic keys. The "on" and "off" positions of the pump can be demonstrated with a FLIP-FLOP operating push-pull on a visual indicator. The circuit was designed by R. L. Humphrey, Bowles Engineering Corp., Silver Springs, Maryland.

M-050

Maas, Margaret A.

FLUIDICS PROTECT PUNCH-PRESS OPERATOR'S FINGERS

Design news, Page 8, September 15, 1965

Logic circuit of five turbulence amplifiers operates punch press when operator's fingers are out of the way. The operator must cover two vents, one on either side of the press with his fingers. Closing the vent sends a signal to the turbulence amplifier circuit which then opens the punchpress air line for one cycle of the press.

M-051

Makarov, I., Dubov, A.

ELECTRONICS, NEW RIVAL

DDC Report AD-607312 (Foreign Tech. Division Air Force System Command), WPAFB, September, 1964, unedited rough draft translation from Izvestuja (USSR), 1964, February 4, Page 5

A report on the new developments in the field of pneumatics is presented. A discussion on the economics of automated pneumatic systems in industrial plants is given. The development of a system of standard pneumatic devices and parts in the USSR industry is also discussed.

M-052

Maker, P.; Mayer, E. A.

CONTROL CHARACTERISTICS OF VORTEX VALVES

See Author Mayer, E. A.

M-053

Malim, T. H.

FLUIDS: THE NEW LOOK IN CONTROLS

Iron Age, July, 1965, Page 53

Summary report of various manufacturers applications of fluid amplifiers. Progress over the past two years indicate that fluid amplifiers are now ready to move from Space R & D to practical use on machine tools, computers, and other places on the shop floor.

M-054

Mamzic, C. L.

FLUID INTERACTION CONTROL DEVICES

Proceedings of the Fifth National Chemical & Petroleum Instrumentation Symposium, Wilmington, Delaware, May 4-5, 1964

Discussion of control devices whose operation is based upon interaction between fluid streams, a high-energy stream being controlled by a low-energy stream. The particular function of each device is dependent upon its geometrical shape. The principles involved can be used to make process control valves, amplifiers, computing and logic elements (analog and digital), and oscillators. Almost any gas, liquid, or slurry can be used in these devices. They offer high amplification and no size limitation, with a wide choice of materials of construction. Oscillators have been made to operate at frequencies of over 10,000 cps. When used as diverting valves, there is no shock or water hammer, and all these devices can operate under extremes of temperature, vibration, or radiation. The Coanda effect, or wall attachment principle, which is the basis for the "memory" function obtainable in these devices, is discussed. Commercially available, solid state pneumatic and hydraulic (SSPH) control valves, with their methods of application, are described in some detail.

M-055

Manion, Francis M.

DEVELOPMENT OF A PRESSURE CONTROLLED OSCILLATOR FOR FREQUENCY MODULATING SYSTEMS

Proceedings of the HDL Fluid Amplification Symposium, Vol. II, October, 1965

A primary component in the development of a frequency modulating system is the Pressure Controlled Oscillator which converts a pressure signal from a sensor into a equivalent frequency.

This section describes the development of a PCO. A schematic is shown with some performance test data in Figure 1. This oscillator has a linear relationship between signal input pressure and output frequency with a conversion rate of over 800 cycles per second per psi and a useful range of 80 cps, (+ 40 cps) when operating around 100 cps.

The oscillator is a feedback type that utilizes a change in jet transport time to change its frequency. This is accomplished by the design of a special feedback circuit to effect the necessary phase shift in the feedback loop to obtain the linear relationship. The development of this oscillator was preceded by a survey of the available types of pure fluid oscillators. The results of this survey indicated that the proportional feedback type was most promising. A conceptional model was then developed with the aid of some experiments. The mathematical study determined the design requirements for a linear characteristic.

M-056

Manion, F. M.

DIFFERENTIAL FLUID AMPLIFIER

U. S. Patent No. 3,209,774, dated October 5, 1965, filed September 28, 1962

This invention relates generally to pure fluid amplifier systems and more specifically to a differential fluid amplifier for comparing and velocity-amplifying pressure differentials between fluid input signals and for converting the velocity-amplified signals to fluid output signals which can be employed to drive load utilization devices utilizing fluid vortex flow for the control or operation thereof.

M-057

Manion, F. M.

EXTERNAL VORTEX TRANSFORMER

U. S. Patent No. 3,216,439 dated November 9, 1965, filed December 18, 1962

This invention relates generally to fluid amplifier systems having no moving solid parts in which amplification is a function of the magnitude of deflection of a fluid power stream by control fluid flow. More particularly, this invention relates to a fluid amplifier utilizing the effects of interaction between a power stream and a control stream in an interaction region, a control stream being produced by a circumferential velocity-amplified rotating fluid input signal, such that a relatively small amount of energy available in the fluid signal controls a considerably larger quantity of energy available in the power stream.

M-058

Manion, Francis, M.; Humphrey, Ronald L.

LOW-PASS FILTERS FOR PNEUMATIC AMPLIFIERS

See Author Humphrey, Ronald L.

M-059

Margolis,D. P.

SOME ASPECTS OF CURVED TURBULENT MIXING IMPORTANT IN FLUID AMPLIFIERS AND FLUID LOGIC DEVICES

Proceedings of the HDL Amplification Symposium, Vol. I, May 26-28, 1964

In a curved turbulent mixing layer the flow is dynamically either stable or unstable depending on whether the radial gradient of angular momentum is positive or negative. In the unstable case, mass entrainment is greater than for either the stable case or a straight mixing layer. The rate of dissipation of turbulent energy is an order of magnitude less in the unstable case than in the stable case. Based on present results a fairly good prediction of the mean velocity profiles is possible.

M-060

Markland, E.; Boucher, R. F.

EXPERIMENTS ON SYMMETRICAL WALL RE-ATTACHMENT AMPLIFIERS

    See Author Boucher, R. F.

M-061

Markland, E.; Oels, R. A.; Boucher, R. F.

EXPERIMENTS ON TURBULENCE AMPLIFIERS

    See Author Oels, R. A.

M-062

Marris, A. W.

ON THE GENERATION OF SECONDARY VELOCITY ALONG A VORTEX LINE

ASME Paper 64-FE-13 presented at the Fluids Engineering Conference, Philadelphia
May 18-21, 1964

    A general expression for the generation of secondary velocity along a
vortex line is developed for the case of incompressible flow with uniform
viscosity; The result is given with various degrees of specialization; i.e. for
unsteady flows, and steady inviscid flows. The formulation for the case of
steady flow in which the direct action of viscosity is discounted is applied
to the rationalization of experimentally observed secondary flow phenomena at
the convex wall for entrance flow in a curved channel of rectangular cross
section.

M-063

Martin, S. B. (Sandia Corp.) Phillips, E. R. (Univac/Sperry Rand)

FLUID TIMER DEVELOPMENT

Substantial advances have been demonstrated in the use of fluids to perform timing functions since the first breadboard timer was constructed. (1) The volume has been reduced by a factor of 60 (2) The number of active elements has been reduced from 100 to 35. (3) Power requirements have been reduced by a factor of 4. (4) Over one thousand flip-flops have been manufactured and (5) The present unit was designed to be environmentally rugged. Areas where additional work will be required before fluids are utilized for ordnance timers are (1) A satisfactory power supply has yet to be domonstrated. (2) Packaging must be improved further. (3) Element size must be reduced and (4) additional environmental test and reliability data must be obtained.

M-064

Massachusetts Institute of Technology

BASIC APPLIED RESEARCH IN FLUID POWER CONTROL

This report describes continuing applied research work on problems related to the design and development of high performance hydraulic and pneumatic control equipment for advanced systems. Sustained emphasis on high pressure pneumatic components and systems reflects a desired ultimate objective of employing hot-gas power to operate such systems. Included in this report are descriptions of work on a Reaction-Jet Servosystem and Study of Losses in Reaction-Jet Motors; Experimental Studies of Bang-Bang Control of a Pneumatic Servomechanism; Pulsed Pneumatic Information Transmission System; Externally Pressurized Journal Bearings; and Flow Characteristics of Small Orifices.

M-065

Massachusetts Institute of Technology

BASIC APPLIED RESEARCH IN FLUID POWER CONTROL

Report No. 8998-4, Department of Mechanical Engineering, Massachusetts Institute
of Technology (Prepared under contract AF33(657)-7535)

This report describes continuing applied research and development work on
problems related to the design and development of high performance hydraulic
and pneumatic control equipment for advanced aerospace systems. Sustained
emphasis on pneumatic components and systems reflects a desired objective of
employing gas power to operate systems which must function under a wide range
of operating temperatures and/or in fields of high intensity radiation. Included in
this report are descriptions of work on reaction jet servomotors, fluid jet
modulators, and gas-lubricated bearings.

M-066

Massachusetts Institute of Technology

BASIC APPLIED RESEARCH IN FLUID POWER CONTROL

DDC Report AD-603195 (MIT Progress Report No. 7 - covering period October, 1963 -
January 31, 1964, contract AF33(657)-7535

The report presents technical results and describes progress in several
phases of continuing applied research and development related to the design and
development of high-performance fluid control devices for advanced aerospace
systems. Continued emphasis is placed on pneumatic components and systems which
are capable of performing over wide ranges of temperature and in the presence
of intense radiation.

The report describes current work in the engineering projects laboratory
dealing with a new pulse actuation system, a pneumatic pulse-length modulated
servosystem, a gas-operated accelerometer, the dispersion of transients in fluid
transmission lines, a new electrostatic pure fluid jet valve, a dirt-insensitive
flapper valve, and gas-lubricated bearings.

M-067

Massachusetts Institute of Technology

BASIC APPLIED RESEARCH IN FLUID POWER CONTROL

MIT Report No. 8998-8 Prepared for Contract AF33(657)-7535, FDL-TDR-64-127,
September, 1964

     This report presents technical results and describes progress in several
phases of continuing applied research and development related to the design and
development of high performance fluid control devices for advanced aerospace
systems. Continued emphasis is placed on pneumatic components and systems which
are capable of performing over wide ranges of temperature and in the presence of
intense radiation. This report describes current work in the Engineering Projects
Laboratory dealing with a new pulse actuation servo system, a pneumatic pulse-
length-modulated servo system, the dynamics of fluid jet modulators, electrostatic
pure fluid modulation, jet pipe inlet coupling, compressible dampers, and gas-
lubricated bearings.

M-068

Massachusetts Institute of Technology

BASIC RESEARCH AND DEVELOPMENT IN FLUID POWER CONTROL FOR THE UNITED STATES AIR
FORCE

WADD Tech. Report 60-675, WWRMPT-1, 4th Progress Report for Contract AF33(616)6120
September, 1960

     This report describes continuing applied research and development work on
vital problems encountered in providing high performance hydraulic and pneumatic
control systems for advanced system design and development. Increased emphasis
on high pressure pneumatic components and systems reflects approach to an
ultimate objective of employing hot gas power to operate such systems. Control
valves, servomotors, gas bearings, and techniques of control are the major items
discussed in this report.

M-069

Massachusetts Institute of Technology

BASIC RESEARCH AND DEVELOPMENT IN FLUID POWER CONTROL, 8th Progress Report - For contract AF33(616)6120, Tech. Report # ASD-TR-61-349, February, 1962

This report describes continuing applied research and development work on problems vital to the design and development of high performance hydraulic and pneumatic control equipment for advanced systems. Increased emphasis on high pressure pneumatic components and systems reflects the approach to an ultimate objective of employing hot gas power to operate such systems. Control valves, servomotors, gas bearings, fluid power and signal transmission, hot-gas contamination and techniques of control are the major items discussed in this report.

M-070

Massachusetts Institute of Technology

BASIC RESEARCH AND DEVELOPMENT IN FLUID POWER CONTROL FOR THE UNITED STATES AIR FORCE

Tech. Documentary report No. ASD-TDR-62-3, 9th Progress Report for contract AF33(616)-612U, January, 1962

This report describes continuing applied research and development work on problems vital to the design and development of high performance hydraulic and pneumatic control equipment for advanced systems. Increased emphasis on high pressure pneumatic components and systems reflects the approach to an ultimate objective of employing hot gas power to operate such systems. Control Valves, servomotors, fluid power and signal transmission, and techniques of control are major items discussed in this report.

M-071

Massachusetts Institute of Technology

ENGINEERING PROJECTS LABORATORY REPORT - EPL-1, JANUARY 1963

M-072

Massachusetts Institute of Technology

REPORT TO THE AIR FORCE ON BASIC APPLIED RESEARCH IN FLUID POWER CONTROL

Report No. 8998-1, Department of Mechanical Engineering, Massachusetts Institute
of Technology. (Prepared under contract AF 33(657)-7535

This report describes continuing applied research work on problems related
to the design and development of high performance hydraulic and pneumatic control
equipment for advanced systems. Sustained emphasis on high pressure pneumatic
components and systems reflects a desired ultimate objective of employing hot-gas
power to operate such systems. Included in this report are descriptions of work
on a Reaction-Jet Servo System and study of friction drag on Reaction-Jet Motors:
experimental studies of a flapper valve in a breadboard pneumatic servomechanism;
development of transmission line theory; fluid jet relays, and a step-by-step
actuator for a pulsed pneumatic information transmission system; cold gas tests
of a hot-gas rate gyro; and flow characteristics of small orifices.

M-073

Massachusetts Institute of Technology

RESEARCH & DEVELOPMENT OF FLUID AMPLIFIERS FOR TURBOPROPULSION SYSTEM CONTROL

Technical Documentary Report NO APL-TDR-64-82, MIT Report DSR 9159-2 Prepared
for Contract AF33(657)-8384, June 30, 1964

Techniques for sensing the relative threat of flow instabilities in jet
engines have been a long sought-after goal. This is the final report of a study
aimed at determining the feasibility of certain types of fluid jet amplifiers,
used as fast pressure and temperature sensors. The background of the project, the
environment in which the fluid sensors must operate, and initial results have
been presented in the first annual report. The more theoretical aspects of the
present report include a study of the statics and dynamics of the interaction of
a fluid jet and a receiver port, the dynamics of the controlled deflections of
jets in fluid amplifiers, and the dynamic analysis of fluid systems. The more
applied aspects include the design of a fluid-relay stall-cell sensor, a fluid
diode possibly useful for sensing blade wakes or stall cells, and a unique
reference-frequency pneumatic oscillator.

M-074

Massachusetts Institute of Technology

RESEARCH & DEVELOPMENT OF A HOT GAS FLIGHT STABILIZATION SYSTEM

WADD Tech. Report 60-449 Part 1, Vol. 1, September, 1960, for Contract
AF33(600) 40538

This volume describes the preliminary requirements for a Hot Gas Flight
Stabilization System applicable to a broad range of advanced vehicles. The
preliminary system described will, through proper scaling of components, meet
the exact stabilization requirements of most or the individual vehicles used
in the analysis. Through the approach used in this Phase I, the feasibility of
a Hot Gas Flight Stabilization system and its applicability to advanced vehicles
have been assured.

M-075

Massachusetts Institute of Technology (Department of Mechanical Engineering)

RESEARCH AND DEVELOPMENT OF PNEUMATIC JET RELAY SYSTEM FOR PROPULSION SYSTEM
CONTROL

Report No. DSR 9159-1 dated March 31, 1963

Fluid jet devices with no moving mechanical parts, which can serve as
rugged sensing and control elements in advanced air-breathing propulsion systems,
are the goal of this study. A basic approach for a quasi-static prediction
for the dynamic behavior of controlled jets is presented, and implemented by a
digital computer. Experimental results of a basic investigation of the impingement
of a turbulent jet onto a flat plate are given for a wide variation of Reynolds
numbers, and compared with theory. The static and dynamic interactions of jets
with receiver ports are discussed, including theoretical and experimental results.

After a discussion of the pressure and temperature environment in which
useful engine-control pressure sensors must operate, two particular approaches
to the sensor problem are presented. The first is a fluid jet relay to detect
large regions of relatively stagnant fluid (rotating stall cells), which can
be indicative of an incipient flow instability, and the second is a blade-wake
sensor based on fluid diodes coupled to volumes. Theory and experiment to
date indicate considerable promise for these devices, although little of the
work presented in this progress report is complete. Finally, topics of related
work at the Engineering Projects Laboratory, and plans for future work as part
of the present contract, are briefly stated.

M-076

Maunoury, Francois; Kadosch, Marcel; Bertin, Jean

FLUID FLOW CONTROL DEVICE FOR JET PROPULSION NOZZLES

French Patent Specification, 759, 659, September, 1954

Describes a device for varying the effective area of the propelling nozzle of a jet propulsion engine, comprising fluid-injecting means opening into said propelling nozzle and extending through a wall of said propelling nozzle over at least a portion of a peripheral zone thereof for forming a screen-like fluid jet issuing into said propelling nozzle in a direction which is generally perpendicular to the axis of said propelling nozzle or inclined upstream with respect to a plane perpendicular to said axis.

M-077

Mayer, E. A.; Maker, P. (Bendix Research Lab.)

CONTROL CHARACTERISTICS OF VORTEX VALVES

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. II, May 1964

A plane vortex has two velocity components, a radial component and a tangential component. The interaction between these components may be used to accomplish a valving function, using no moving mechanical elements other than the fluid flows. This feature makes the vortex valve a desirable control element in the output stages of fluid power systems.

M-078

Mayer, Endre A.

PHOTOVISCOUS FLOW VISUALIZATION IN FLUID STATE DEVICES

Proceedings of the HDL Fluid Amplification Symposium, Vol. II, October, 1965

Photoviscosity is an excellent flow visualization technique applicable to a variety of fluid state components. A number of liquids exhibit double refracting properties which are a function of the viscous shear stress exerted on the liquid. The viscous shear is proportional to the velocity gradient in liquids, and the interference pattern is thus a function of the flow field. The photoviscous art was advanced significantly by F. A. Peebles, et. a., in 1953 by reporting in detail on the photoviscous properties of a Milling Yellow Dye (MYD) solution. The MYD solution is highly sensitive, easy to prepare and handle, and the viscosity is similar to that of hydraulic oils. These properties made the MYD a desirable solution for photoviscous studies.

M-079

Mc Cabe, J. T.; Carfagno, S. P.

SUMMARY OF INVESTIGATIONS OF ENTRANCE EFFECTS IN CIRCULAR THRUST BEARINGS

Franklin Institute Interim Report 1-A2049-24 prepared for contract NONr-2342 (00) Task NR-062-316

     See Author Carfagno, S. P.

M-080

McCloy, D.; McGuigan, R. H.

SOME STATIC AND DYNAMIC CHARACTERISTICS OF POPPET VALVES

Paper 23, December 30, 1964

     The poppet valve is commonly found in relief valves, pressure regulators, and selectors, but it has seldom been used as a means of proportional control, mainly because it has been claimed that it has violently non-linear flow and force characteristics at small openings. In this paper a study is made of discharge co-efficients and flow forces in the poppet valve. It is shown that different flow patterns can exist and that these can affect the flow forces. The results indicate that the seat geometry has a profound effect on the flow characteristics. Dynamic effects are also considered, and it is shown that when the valve is oscillating, the discharge coefficient differs from the static one.

M-081

McGuigan, R. H.; McCloy, D.

SAME STATIC & DYNAMIC CHARACTERISTICS OF POPPET VALVES

     See Author McCloy, D.

M-082

Mc Leod, P. C.; Testerman, M. K. (Phillips Petroleum Co.)

METHOD AND APPARATUS FOR DETERMINING FLUID FLOW RATE

U. S. Patent No. 3,144,767 dated August 18, 1964, filed July 3, 1961

     See Author, Testerman, M. K.

M-083

McRee, Donald I.

EXPERIMENTAL STUDY OF A CONVERGENT NOZZLE AND FREE JET FLOW

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965

An experimental study is made of the two-dimensional convergent nozzle which was theoretically analyzed in a companion paper. Experimental results are compared with the theoretical analysis. Velocity profiles, jet core lengths, pressure loss due to mixing downstream of the nozzle exit, mass flows, and discharge coefficient are presented for jet supply pressures of approximately 16 to 31 psia. In most cases the experimental and theoretical results compared very favorably and demonstrated the usefulness of theory in predicting jet behavior.

M-084

McRae, R. P; Harvey, D. W.

EXPERIMENTAL STUDY OF FLUID CONTROLLED VALVES

See Harvey, D. W.

M-085

McRae, R. P.; Harvey D. W.

STEADY FLOW IN A PURE FLUID VALVE TVC SYSTEM

See Author Harvey, D. W.

M-086

Meek, J. M.

ANGULAR RATE SENSOR UTILIZING AT LEAST ONE FLUID BEAM

U. S. Patent No. 3,205,715 dated September 14, 1965, filed April 18, 1962

This invention relates to rate measuring devices and more particularly to a device and apparatus for measuring the angular rate of rotation of a body about one or more of its axis, and requires no moving parts other than the stream of fluid particles.

M-087

Mehus, T.

AN EXPERIMENTAL INVESTIGATION INTO THE SHAPE OF THRUST AUGMENTING SURFACES IN CONJUNCTION WITH COANDA - DEFLECTED JET SHEETS, Part II

DDC Report AD614617 (Institute for Aerospace Studies, University of Toronto, Ontario, January, 1965

The present work is a continuation of the experimental investigations described in AD-611 759. The purpose was to increase the thrust augmentation of a configuration consisting of a coanda surface (quadrant), deflecting the primary jet sheet through 90 degrees, in conjunction with additional (thrust augmenting) surfaces. The effect of a horizontal and vertical gap between the lip of the nozzle and the leading edge of the deflection surface, as well as the effect of a gap between its trailing edge and the downstream diffuser wall (tertiary flow) was studied. These experiments were carried out for a convergent (subsonic) and a convergent-divergent (supersonic) nozzle at various pressure ratios. The subsonic jet sheet produced the highest thrust augmentation. Tilting of the quadrant led to an increase in the augmentation ratio (excluding the lift acting on the nozzle), while the total thrust augmentation (including the lift over the nozzle) did not increase. Typical secondary and exit mixed flow velocity profiles were obtained.

M-088

Mellor, G. L.; Gibson, D. M.

EQUILIBRUM TURBULENT BOUNDARY LAYERS

DDC Report AD601276 (Princeton University) Contract NONR1858 38, November, 1963

A particular form for an effective or eddy viscosity is hypothesized and considered in conjunction with the boundary layer equations for cases where the pressure gradient parameter is held constant. Precise solutions are obtained for accelerating and decelerating flows in the range, beta infinity; the solutions span the complete boundary layer profile with the exception of the small viscous sublayer region. Comparison of the calculated velocity profiles with zero pressure gradient data and Clauser's and stratford's decelerating flow data is excellent. For large values of beta the influence of the pressure gradient dominates the influence of the wall shear stress; defect profiles should then be presented in the form, U Sub P, Instead of U sub Tau where U sub P is a pressure velocity and U sub Tau is the conventional skin function velocity.

M-089

Metzger, Eric, E.; Bauer, Peter

DIGITAL DATA HANDLING SPEEDS WITH PURE FLUID (PNEUMATIC) CIRCUITS

See Author Bauer, P.

M-090

Metzger, Eric E.; Lomas, Charles G.

TURBULENCE AMPLIFIER FOR INTEGRATED TWO-DIMENSIONAL FABRICATION

Proceedings of the HDL Fluid Amplification Symposium, Vol. II, October, 1965

Large and complex logic circuits use considerable power. The power consumption can be minimized by reducing the power consumption per stage, and the number of stages. One way to achieve these goals is to use turbulence amplifiers, with their low flow rates and low power jet pressures, and their ability to accept a large number of inputs without interaction.

Heretofore, turbulence amplifiers have been manufactured in three-dimensional configurations, requiring elaborate interconnecting manifolds of tubing when assembled into logic packages. Reliability considerations dictate an integrated structure for use in military equipment. In order to demonstrate the feasibility of using turbulence amplifiers in military structures, with the attendant savings in power and circuit complexity, it is necessary to produce the same "solid state" manifolds as is used by jet deflection and boundary effect amplifier circuits.

This report describes the development and demonstration of a turbulence amplifier "and" gate in "optiform".

M-091

Meyer, C. H. (New York Central System)

A FLUID OPERATED DIESEL LOCOMOTIVE TRANSITION CONTROL UNIT

Proceedings of the 3rd Fluid Amplification Symposium, Vol. III, October, 1965

The New York Central Railroad has initiated a development program applying fluid logic to the traction motor control circuits in locomotives. The first phase of this program was initiated late in 1964. In March of 1965, a contract was awarded to Sperry Rand's univac Division and by May 15, 1965, the first fluid logic equipped locomotive was operating in normal road-freight service. The objective of this paper is to briefly describe normal electrical control of this locomotive and to review the development steps leading to a successful installation of fluid logic control.

M-092

Meyer, J. (M. D.) - Straub, H. H. (Harry Diamond Labs)

AN EVALUATION OF A FLUID AMPLIFIER, FACE MASK RESPIRATOR

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. III, October, 1965

See Author Straub, H. H.

M-093

Miles, John W.

ON PANEL FLUTTER IN THE PRESENCE OF A BOUNDARY LAYER

DDC Report AD605759 (TRW Space Tech. Lab. Los Angeles, California) for contract AF18 600 1190, December, 1957

The energy transfer from the uniform flow outside a boundary layer to a transverse surface wave at the boundary is calculated on the hypothesis that the boundary layer may be represented by an inviscid approximately parallel shear flow. This energy transfer is found to consist of two components; the first is similar to that found previously for supersonic panel flutter in the absence of a boundary layer and is relatively diminished by the presence of the boundary layer; the second is intrinsic to the shear flow and is present whenever the surface wave speed is smaller than the free stream speed (whether subsonic or supersonic). The application of the results to actual flutter calculations is discussed and an example of a pressurized cylinder considered. It is concluded that the presence of a typical boundary layer may reduce the degree of instability for supersonic flutter of a long, monocoque shell by an order of magnitude; thereby providing a possible explanation of discrepancies between earlier theories (in which boundary layer effects were neglected) and observation.

M-094

Miller, David P.

CHARACTERISTICS OF A VORTEX FLUID THROTTLE

Proceedings of HDL 2nd Fluid Amplification Symposium, Vol. II, May, 1964

Experimental studies were conducted to determine performance characteristics of a fluid throttle in which secondary air is injected upstream of the nozzle throat tangentially to the wall so as to produce a vortex in the converging section. Conservation of angular momentum requires that the swirl which is produced by the injection must increase through the convergent section of the nozzle. As a result, the axial flow rate is reduced by the flow being forced to follow a helical path of continuously decreasing pitch and by the loss in total pressure resulting from the viscous turbulent mixing of the secondary and primary flows. Data are presented showing static pressure at the wall and pitot pressure along the certerline of the cylindrical chamber ahead of the nozzle as a function of injectant total pressure. The effect of the number and area of the injection ports and of the injection Mach number on the throttling effectiveness of the vortex throttle is also presented. The data are compared with an approximate inviscid theory for swirling flow through a nozzle and its applicability to predicting vortex throttle performance is discussed. Finally, the data for the vortex throttle are compared with the data for a fluid throttle in which air was injected into the throat of a similar nozzle from a circular annulus radially and upstream at angles of 60 and 45 deg relative to the direction of flow.

M-095

Miller, David P.; Olson, Robert E.

THE INTERACTION OF OBLIQUE SHOCKS & EXPANSION WAVES WITH A JET BOUNDARY MIXING ZONE

See Author Olson, Robert E.

M-096

Misra, A. K.; Foster, K.

THE TURBULENT REATTACHMENT AMPLIFIER IN A CONVENTIONAL PNEUMATIC CIRCUIT

See Author Foster, K.

M-097

Mitchell, A. E. (IBM, Zurich); Müller, H. R.

COMPARISON OF A MOMENTUM DEVICE WITH A TURBULENT REATTACHMENT DEVICE

    Comparison of the performance characteristics of two types of fluid jet amplifiers: the momentum amplifier and the boundary-layer amplifier. The total response time is about the same for both devices, but the boundary-layer amplifier incorporates the following advantages (1) a flow gain of about 20 vs. 2.5 for the momentum amplifier (2) a control line resistance of about 3 vs. 0.8 and (3) stability at high receiver loads, due to guidance of the main jet by the walls.

M-098

Mitchell, A. E.

REATTACHMENT OF SEPARATED BOUNDRY LAYERS AND THEIR EFFECTS IN FLUID SWITCHING DEVICES

    A description of phenomena associated with the reattachment and separation of fluid jets and their effects in various fluid devices is given. The way these phenomena can be used and the way in which they influence the performance of fluid switching devices is described.

M-099

Mitchell, D. G.; Duff, J.; Foster, K.

SOME EXPERIMENTS ON THE VORTEX VALVE

    See Author Duff, J.

M-100

Mitchell, A. E.; Müller, H. R.; Zingg, R. H. W.

SOME RECENT DEVELOPMENTS IN THE DESIGN OF FLUID SWITCHING DEVICES AND CIRCUITS

The 1964 Fluid Power International Conference

This paper describes some of the recent developments in the design of fluid logical devices, which do not use moving mechanical parts. They use only fluid mechanical effects to cause the switching of the streams. These developments include the design of pulsed devices. Two techniques are discussed which allow these fluid circuits to be reproduced in light-sensitive materials directly from master drawings. In miniaturized circuits the effect of manufacturing imperfections becomes important. The results of an investigation of some non-rectangular cross-sections are given.

M-101

Mon, George; Joyce, James: Straub, Henry; Woodward, Kenneth

FOUR FLUID AMPLIFIER CONTROLLED MEDICAL DEVICES

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. IV, May 26-28, 1964

See Author Woodward, Kenneth

M-102

Monge, M. (Riv Sezione Calibri e strunenti, Torino, Italy)

HANDLING "FLUIDICS" FOR PRACTICAL APPLICATIONS

Paper given at the First Conference on Fluid Logic and Amplification Sponsored by the British Hydromechanics Research Association and College of Aeron. Cranfield, England, September 9-10, 1965

M-103

Moore, C. B. (Moore Products Company)

CONTROL APPARATUS

U. S. Patent No. 3,177,888 dated April 13, 1965, filed September 21, 1962

It is the object of this invention to provide apparatus for controlling the positioning of a jet in which a throttling action and an on-off action can be obtained as desired.

M-104

Morgan, James I.

FLUID-POWER COMPONENTS

ASME Publication 65-MD-29, June, 1965

Miniaturization of fluid-power components is currently taking place in two announced manners. Components are being shrunk in size. Other very small components have been and are being developed using entirely new operating principles, thereby replacing the commonly used larger devices now available. This paper shows an outstanding example of just shrinking component size. However, the major portion of this paper will deal with the new miniature fluid control devices called fluid amplifiers. Size, weight and price comparisons for comparative logic units and for an entire machine control will be made to show the outstanding savings resulting from miniaturization. The final conclusion is that as a result of miniaturization of fluid-power components machines operated by fluid power also be economically and reliably controlled by fluid-power means rather than by electrical means.

M-105

Morton, T. (Aviation Electric Limited, Montreal)

THE USE OF A FLUID AMPLIFIER IN AN INTERMITTENT STREAM RELEASE VALVE FOR HIGH ALTITUDE RESEARCH

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. III, October, 1965

An intermittent stream valve incorporating a bistable fluid amplifier has been designed for modulating a stream of liquid ejected from a gun-launched high-altitude vehicle. The adaptation of fluid amplifier techniques results in an intermittent valve which is light-weight simple, and extremely rugged. The valve operates over a wide range of input pressures and has a wide environmental tolerance band. The principle of the valve circuit appears adaptable to other applications where the modulation of an incompressible fluid stream is required and where the inherent size cost and environmental tolerance features of fluid devices may be of advantage.

M-106

Moynihan, F. A.; Reilly, R. J.

DEFLECTION AND RELATIVE FLOW OF THREE INTERACTING JETS

Deflection of a power stream by means of interaction with unbalanced control streams, a phenomena basic to fluid amplifiers, was investigated experimentally. An expression for the combined stream deflection in terms of the acting forces is derived and verified by detailed measurements for two-dimensional incompressible flow. Presence of free boundaries and viscosity make it difficult to solve the jet deflection equation explicitly in terms of amplifier design parameters so the relation of the interaction forces, as they affect the jet deflection, and the relative mass flows of the three streams were determined experimentally for a range of amplifier design variables. It is shown that all the forces (momentum, static pressure and centrifugal) are significant in determining the deflection and that their relative importance is a function of the control stream average pressure for both small and large control ports. Average control stream mass flow, relative to the power stream mass flow is essentially independent of jet deflection and is a function of the geometry and average control stream total pressure.

M-107

Moynihan, F. A.

JET INTERACTION NOISE

Experience with proportional fluid amplifiers has shown that noise in the form of pressure fluctuations is generated within the device even after minimizing and/or eliminating the obvious noise sources such as roughness, fluid inpurities and flow separation conditions caused by strong positive static pressure gradients. An additional possible noise source, the jet interaction process of the power and control streams, was investigated by measurements of the velocity fluctuations in the combined jets using a hot-wire anemometer technique. Variables, for the experiments, include the geometry of the control and power streams as well as their relative pressure levels. It was found that the various shear layers, formed by the velocity discontinuities of the power and control streams, can be a significant noise source at upstream stations where a simple free jet would be relatively quiet.

M-108

Mueller, Thomas, J. & Olson, Robert E.

SPREADING RATES OF COMPRESSIBLE TWO-DIMENSIONAL REATTACHING JETS

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-28, 1964

The results of an investigation of the spreading rates of compressible two-dimensional reattaching jets and tangential wall jets are reported. For the reattaching jets four initial jet Mach numbers - two subsonic and two supersonic - were investigated for each of two setback distances and two angles of the adjacent wall. Three initial jet Mach numbers - two subsonic and one supersonic were employed for the tangential wall jet. These data are presented along with previously reported free jet data.

Velocity profiles were obtained from a combination of pitot pressure surveys across the jet and static pressure measurements along the wall and jet-centerline by assuming a constant total temperature throughout the jet.

Values of the spread parameter were obtained for each type of jet flow by fitting the nondimensional velocity profiles to the Gaussian profile and the error function profile in the region where the velocity ratio is 0.5. Using these values of the spread parameter, a comparison was made of typical experimental nondimensional velocity profiles with the theoretical error function and Gaussian velocity profiles. The significance of this comparison and the spreading rates obtained are discussed in relation to the velocity profile development characteristics of jet flows in fluid amplifiers.

M-109

Müller, H. R.

A STUDY OF THE DYNAMIC FEATURES OF A WALL-REATTACHMENT FLUID AMPLIFIER

The American Society of Mechanical Engineers, Paper 64-FE-10, dated May, 1964.
Also, Journal of Basic Engineering, Vol. 86, December, 1964, Pages 819-826

The paper describes the characteristics of a wall-reattachment fluid amplifier. The switching of the jet from the wall to which it is attached to the opposite one is analyzed. It is shown that the control input characteristic that is measured statically can be applied in the dynamic case. This fact is far from being trivial, as the transient flow patterns occurring during the switching process are basically different from the stationary patterns. The variation of the response time (time interval between when a control pulse is applied at the control port and when the output signal is received at the other receiver) with the control supply pressure is given and compared with the results obtained from a simple analytical switching model. For a control supply pressure of 40 per cent of the supply pressure, the response time is 5 to 8 times the transport time of a particle travelling 20 times the nozzle distance.

M-110

Müller, H. R.; Mitchell, A. E.

COMPARISON OF A MOMENTUM DEVICE WITH A TURBULENT REATTACHMENT DEVICE

IBM Corp. Zurich Research Lab, Rüschikon - Zurich Switzerland, February 26, 1964
Also IAA Report A64-11716

The jet profile of a momentum amplifier is used to find the optimum distance
between a receiver and outlet nozzle, as well as the most favorable receiver width.
With the help of the output characteristic and of the control line resistance,
the response time can be calculated. With equal discrimination, without considering
response time, the boundary layer amplifier allows essentially higher amplification.

M-111

Müller, H. R.; Zingg, R. H.; Glaettli, H. H.

REMARKS ON THE LIMITATIONS OF PURE FLUID ELEMENTS

See Author Glaettli, H. H.

M-112

Müller, H. R.; Mitchell, A. E.; Zingg, R. H. W.

SOME RECENT DEVELOPMENTS IN THE DESIGN OF FLUID SWITCHING DEVICES AND CIRCUITS

See Author Mitchell, A. E.

M-113

Müller, H. R.

WALL REATTACHMENT DEVICE WITH PULSED CONTROL FLOW

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-28, 1964

The flow gain characteristics of a monostable wall reattachment fluid
amplifier show clearly that for high flow gain, a double-sided element is superior
to a single-sided one. The effective angle $\theta*$ (angle between the deflected jet and
the adjacent wall, shortly before switching) has been determined for different
aspect ratios and wall lengths, and is compared with the results of Bourque and
Newman. It can be seen that at large wall lengths, the author's curve approaches
the curve of Bourque et al, though their results have been obtained with an element

M-113 (Continued)

Müller, H. R.

WALL REATTACHMENT DEVICE WITH PULSED CONTROL FLOW

where the angle θ^* was varied by changing the wall angle θ; whereas in the author's experiment, the angle θ was increased by the injection of control flow.

The optimization of a bistable wall reattachment amplifier with respect to flow and pressure gain is reported. The parameters found to be most important are the wall offset and the control channel resistance R_c.

The switching mechanism has been observed by flow visualization and an attempt is made to describe the switching mechanism by a simple analytical model. A comparison with measured response times is given. Response time measurements have also been carried out with pulsed control flow. The results suggest that control flow has to be injected until the separation bubble has been filled up to such an extent that the switching process becomes self-sustaining. With a control pulse duration time of 40 times the transport time t'_T, and a control supply pressure of 0.7 times the supply pressure, the jet could still be switched over. The control pulse duration time was 30% of the response time measured under normal conditions.

M-114

Murphy, F. E., Jr.; (Corning Glass Co.)

STABLE FLUID AMPLIFIERS

U. S. Patent No. 3,181,545 dated May 4, 1965, filed September 26, 1962

This invention relates to fluid amplifiers and more particularly to mono-and multiple-stable fluid amplifiers wherein a main power stream may be diverted to and locked-on any desired outlet or passageway.

N-007

National Bureau of Standards

FLUID AMPLIFICATION

U. S. Department of Commerce Report, May, 1965

   Significant reports covering the period since 1960 were selected for this
study with reference to earlier works. To date, some computer devices have been
developed based on the Coanda effect and some systems have been devised by
combining these devices. Certain 1962 reports are included in the " Review"
because of their pertinence.

N-008

Nelson, D. J.; Iwata, H. (Marquardt Corp.)

APPLICATION OF PURE FLUID LOGIC TO ON-OFF CONTROL SYSTEMS

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. IV, May 26-28, 1964

   Digital techniques are broadly classfied into: (1) arithmetic and (2) pure
logic. It is noted that many control problems can be solved by using the latter
technique.

   Since, in general, there are alternative ways of representing the same
Boolean function, the pure-logic decoding network can usually be simplified.
Methods are outlined by which this can be done. In many application, the output
decoding can be restricted to two states which implies piecewise linear or on-off
control. This technique was applied to a pure fluid control system. The resulting
minimal logic circuit and exploratory systems synthesis are presented.

N-009

Nelson, S. E.; Brown, F. T.

STEP RESPONSE OF LIQUID LINES WITH FREQUENCY DEPENDENT EFFECTS OF VISCOSITY

ASME Paper 64-WA/FE-6, December 3, 1964

   See Author Brown, F. T.

N-010

Norwood, R. E. (IBM)

ELECTRO-FLUID APPARATUS

U. S. Patent No. 3,187,762 dated June 8, 1965, filed December 10, 1962

The primary objective of this invention is to provide a fluid control element in which the power stream may be switched to a selected channel by either electrical or fluid pressure signals independently of each other.

N-011

Norwood, R. E.;

FLUID LOGIC DEVICE

U. S. Patent No. 3,128,040, April 7, 1964

This invention relates to fluid logic devices, and more particularly to those capable of performing logic functions in a fluid digital computer apparatus.

N-012

Norwood, R. E.

MULTI-STABLE FLUID DEVICE

U. S. Patent No. 3,128,039 dated April 7, 1964

This invention relates to multi-stable fluid devices, and more particularly to multi-stable devices embodying at least one pair of bistable and monostable fluid switching elements coupled to provide a fluid flip-flop device and capable of being cascaded to form a multi-stage binary counter.

N-013

Nystrom, K. S. (Research Institute of National Defense, Sweden)

CONTROL OF A BOUNDARY LAYER "FLUIDIC" BY MEANS OF DISRUPTIVE DISCHARGE

Paper given at the First Conference on Fluid Logic and Amplification, September 9-10, 1965, Sponsored by the British Hydromechanics Research Association and College of Aeron. Cranfield, England.

O-008

Obliven, A. N.; Romanenko, P. N.; Leont'EV; A. E.

A STUDY OF RESISTANCE AND HEAT EXCHANGE IN THE MOTION OF HEATED AIR IN DIFFUSORS AND MIXERS.

DDC Report AD601244 (Aerospace Technology Division, Library of Congress)

See author Romanenko, P. N.

O-009

O'Connor, T. J.; Comfort, E. H.; Cass, L. A. (AVCO Corp.)

TURBULENT MIXING OF AN AXISYMMETRIC JET OF PARTIALLY DISSOCIATED NITROGEN WITH AMBIENT AIR*

Paper No. 65-823 presented at the AIAA Aerothermochemistry of Turbulent Flows Conference Held December 13-15, 1965

Radial and axial variations of fluid properties, i.e., velocity, enthalpy, concentration, and density, in free, compressible, turbulent jets of partially dissociated nitrogen ($T_s = 5800°K$) issuing into ambient air were determined experimentally. Investigations were confined to the near flow fields of the jets produced by an electric-arc plasma generator, since 90% of the change in jet centerline properties occured within 45 nozzle radii. Radial property variations were well represented by the Gaussian curve usually found in studies of cold turbulent jets. Integration of the observed radial profiles at several axial stations demonstrated that jet fluid, energy, and momentum fluxes remained constant ($\pm 10\%$) at each station. Centerline jet fluid concentration decayed most rapidly with axial distance; centerline enthalpy, in turn, decayed more rapidly than velocity. Jet centerline velocity decay was more rapid than predicted by incompressible formulations and less rapid than that found in recent investigations of high-temperature jets of low Mach number. Experimental data obtained in these studies were in excellent agreement with the recent integral analysis of Gray.

O-010

Oels, R. A.; Boucher, R. F. and Markland, E. (University of Nottingham, U. K.)

EXPERIMENTS ON TURBULENCE AMPLIFIERS

Paper given at the First Conference on Fluid Logic and Amplification sponsored by the British Hydromechanics Research Association and the College of Aeron. Cranfield, England.

O-011

Oldenburger, R; D'Sonza, A. F.

DYNAMIC RESPONSE OF FLUID LINES

Journal of Basic Engineering, Trans. ASME, September, 1964, Pages 589-598

O-012

Oldenburger, Rufus and Goodson, R. E.

SIMPLIFICATION OF HYDRAULIC LINE DYNAMICS BY USE OF INFINITE PRODUCTS

ASME Paper No. 62--WA-55, Transactions of the ASME Journal of Basic Engineering

　　See Author Goodson, R. E.

O-013

Olsen, R. E; Stoeffler, R. C. (United Aircraft)

A STUDY OF FACTORS AFFECTING THE TIME RESPONSE OF BISTABLE FLUID AMPLIFIERS

American Society of Mechanical Engineers, Fluids Engineering Division, Conference Symposium on Fully Separated Flows, Philladelphia, Pennsylvania, May 18-20, 1964

　　　Presentation of an analytical method for predicting the time response associated with shifting the reattachment location of a two-dimensional jet reattaching to an inclined plate subsequent to introducing flow into the separation bubble. The procedure is based on a quasi-steady analysis of the flow in the separation bubble and employs a flow model similar to that proposed by Korst for calculation of two-dimensional base pressures with base bleed. Predicted response times are presented for a range of (1) plate setback distances (2) plate angles and (3) jet Mach numbers; and the significance of these results in determining

O-013 (Continued)

Olsen, R. E.; Stoeffler, R. D.

A STUDY OF FACTORS AFFECTING THE TIME RESPONSE OF BISTABLE FLUID AMPLIFIERS

the response time associated with power jet switching in a bistable fluid jet control element is discussed. Also presented are experimentally determined steady-state jet reattachment characteristics which were employed in the response time calculations.

O-014

Olson, R. E.; Kepler, C. E. (United Aircraft)

BISTABLE FLUID VALVE

U. S. Patent No. 3,135,291 dated June 2, 1964, filed June 14, 1961

    See author, Kepler, C. E.

O-015

Olson, R. E. & Camarata, J. F.

PRESSURE RECOVERY CHARACTERISTICS OF COMPRESSIBLE TWO-DIMENSIONAL FREE JET FLOWS

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965

    Results of an experimental investigation of the pressure recovery character-istics of subsonic, compressible, two-dimensional, free jet flows are presented for a range of diffuser geometries. The weight flow characteristics of the diffusers and at various stations within the diffusers for a range of diffusers are presented together with velocity profiles upstream of the diffusers and at various stations within the diffusers for a range of diffuser back pressures.

    An analytical procedure is developed for predicting diffuser performance for a range of jet Mach numbers, diffuser capture heights and diffuser back pressures. Results obtained from this analytical procedure are presented and compared with the experimental results. Good agreement is shown between the analytical and experimental results for the range of variables investigated.

0-016

Olson, Robert E.; Mueller, Thomas J.

SPREADING RATES OF COMPRESSIBLE TWO-DIMENSIONAL REATTACHING JETS

See Mueller, Thomas J.

0-017

Olson, R. E.

SPREADING RATES OF COMPRESSIBLE TWO-DIMENSIONAL REATTACHING JETS UPSTREAM OF REATTACHMENT

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965

The results of experimental studies to determine the spreading rates of two-dimensional reattaching jets upstream of reattachment are presented for a range of jet Mach numbers between 0.66 and 2.0 and a range of geometries both with and without flow into the separation bubble. The jet spreading rates are presented in terms of the shear stress constant in Prandtl's expression for the eddy viscosity. The values of shear stress constant were determined from velocity profile measurements perpendicular to the jet centerline at various axial stations upstream of reattachment.

The results presented indicate that the variation in the spreading rate of the jet boundary enclosing the separation bubble can be correlated with the Jet Mach number and the percentage distance to reattachment for a range of geometries and flow rates into the separation bubble. The spreading rates for the outer boundary of the jet were found to correlate with Mach number and the jet radius of curvature.

0-018

Olson, Robert E.; Miller, David P.

THE INTERACTION OF OBLIQUE SHOCKS AND EXPANSION WAVES WITH A JET BOUNDARY MIXING ZONE

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-28, 1964

Studies of the interaction of oblique shocks and expansion waves with a jet boundary mixing zone were conducted and analytical procedures are presented for computing the location and strength of the reflected waves associated with such interactions. The procedures involve a graphical step-wise calculation with the mixing zone divided into a finite number of constant Mach number regions. Results obtained from the analytical procedures for upstream Mach numbers of 2.0 are presented and shown to be in good agreement with experimental results. Also presented is an illustration of the applicability of the analytical procedures described to the prediction of pitot pressure profiles at various stations in a representative fluid amplifier.

O-019

Orner, P. A. (Giannini Controls Corp.)

DEVELOPMENT OF A PURE FLUID POWER AMPLIFIER

The design and development procedure for a high performance fluid state
power amplifier is presented. The operating principle is based on the controlled
separation of a jet from a curved surface.

Design procedures for adjustment of the amplifier range, gain and input
impedance are described. In one configuration, average power gains greater than
70:1 over the full range from zero to maximum output flow were achieved with
output power levels on the order of 100 watts. Extremely high incremental power
gains, greater than 100 : 1 over a smaller range, were obtained in another
configuration designed for infinite input impedance operation.

O-020

Orner, P. A.; Wilson, J. N. (University of Saskatchewan)

FLUID STATE HYBRID CONTROL SYSTEMS

This paper assesses the simultaneous use of both proportional and bistable
fluid state devices in synthesizing closed loop control systems. In particular,
the desirable features of systems using proportional devices in the power amplifier
and actuator sections of the system and digital devices in the feedback and
compensating sections are presented. The advantages of typical systems are
evaluated with respect to accuracy, speed of response, compensation, stability,
impedance matching, and efficiency. Preliminary experimental results are reported.

O-021

Orner, P. A.

ON THE DYNAMICAL CHARACTERISTICS OF FLUID AMPLIFIERS AND ELEMENTS

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965

The problem of intrinsic instability in fluid jet amplifiers is examined.
Both linear and nonlinear oscillations are discussed. Various pertinent aspects of
the acoustic feedback loop theory for sustained oscillations in a jet-edge system
are conceptually applied to the stability of beam amplifiers. Some experimental
data showing self-induced high frequency oscillations in a vented proportional
beam amplifier are presented.

O-022

Osborn, M. J. (General Electric Company)

FLUID AMPLIFIER STATE-OF-THE-ART

Volume II Bibliography (NASA Report CR-102) Prepared for George C. Marshall
S. F. C. under contract NAS 8-5408, December 3, 1963

The search was limited to no-moving part fluid devices and representative
sources for basic technology. The period from 1935 to the present was covered.
The bibliography includes 317 references, of which 210 have been abstracted.
No appreciable effort was identified in the period from 1935 until early 1960;
most of the references have appeared during the last two-and-a-half years. There
was no specific information on Russian progress in the field. The bibliography
is organized to present references by author in alphabetical order. A subject
index is also given with cross-reference identifications to the author index.

O-023

Osterle, J. F.; Rouleau, W. T.; Young, F. J.; Angrist, S. W.

UNCONVENTIONAL METHODS FOR INFLUENCING FLUID FLOW

Tech. Doc. Report No. ASD-TDR-63-776, Volume I, Prepared by the Carnegie Inst.
of Technology, Pittsburgh, Pa., for contract AF33(657)-9914, November, 1963

A number of related problems concerning the utilization of unconventional
effects for the purpose of affecting the behavior of fluids are investigated.
Effects capable of directly converting thermal or electrical power into pumping
power without the use of moving mechanical parts are studied. A means of
improving the thermoelectric cooling of liquids is investigated. A way of
decontaminating fluids by an electrical effect is studied. Finally, a scheme
for suppressing pressure surges in flowing fluids is examined.

O-024

Otsap, B. A. (Marquardt)

EXPERIMENTAL STUDY OF A PROPORTIONAL VORTEX FLUID AMPLIFIER

An experimental investigation was conducted on a vortex-controlled proportional fluid amplifier exhibiting unique characteristics of high pressure gain of 200 high pressure recovery, fast response and high signal-to-noise ratio. The performance characteristics were investigated, analyzed and are presented in terms of nondimensional quantities and nondimensional design parameters. The adaption of the high pressure gain of a fluid amplifier to network application is presented. An approach to staging and circuit application is presented with suggested notation and schematization. Performance comparison to "pressure controlled" and "Momentum Controlled" fluid amplifiers are presented utilizing nondimensional parameters.

P-012

Parker, G. A. (University of Birmingham, U. K.)

DIGITAL FLUID POSITION ENCODERS

Paper given at the First Conference on Fluid Logic and Amplification sponsored
by the British Hydromechanics Research Association and College of Aeron. Cranfield,
England, September 9-10, 1965

P-013

Pashintseva, V. I.; Lanin, N. D.

METHODS OF CONSTRUCTING PNEUMATIC COMPUTORS OF CONTINUOUS ACTION AND WAYS OF
UTILIZING THEM

   See Author Lanin, N. D.

P-014

Pasternak, E.; Schaffer, R. R.; Akmenkalns, I. G.

PNEUMATIC TO ELECTRIC TRANSDUCERS

   See Author Akmenkalns, I. G.

P-015

Pavlin, C. (Bertin & Cie, France)

EXPERIMENTAL STUDY OF A PROPORTIONAL FLUID AMPLIFIER

Proceedings of the HDL 3rd Fluid Amplification Symposium, Volume III, October, 1965

   An amplifier has been designed and tested which applies the principle of
the lever to aerodynamic jet deflection. The device yields good performances
as a mass flow amplifier and provides facilities for matching impedances between
stages. It can operate as a differential pressure sensor.

P-016

Pavlin, C.; Kadosch, M. (Société Bertin & Cie, France)

MECHANICAL CHARACTERISTICS OF A PURE FLUID RESPIRATOR WITH CURVED WALLS

Paper given at the First Conference on Fluid Logic and Amplification, September 9-10, 1965, sponsored by the British Hydromechanics Association and college of Aeron. Cranfield, England.

P-017

Pavlin, C. (Bertin & Co. La Garenne - Colombes (Seine) France)

THRUST VECTOR CONTROL USING A BLEED OFF-REINJECTION DEVICE

Proceedings of the HDL 2nd Fluid Amplification Symposium, Volume IV, May 26-28, 1964

During the past years, a sudden change in rocket guidance policy has occurred with a more and more marked tendency towards a purely aerodynamic vectoring through direct action on the propulsive gaseous jet.

The main advantages generally put forward in support of this method are suppression of gimbaled nozzles; increased rigidity of structures, allowing to lighten them; suppression of coupling between the nozzle and the rocket motions; flexibility of use; quickness of response, allowing to reduce the overall needs in vectoring, all these advantages being likely to lead a favourable weight balance.

Liquid injection piloting has essentially been investigated so far, on account of easiness of development, but it is generally recognized that this can only be a step towards the injection of hot gases, permitting to obtain markedly higher performances, both in vectoring intensity (20% vectoring is currently reached without appreciable gain drop) and in consumption (twice as economical as the best reactive liquids)

P-018

Pay, Rex

PURE-FLUID GUIDANCE ADVANCES THROUGH RESEARCH AT GIANNINI

Missiles and Rockets, December 9, 1963, Pages 28, 31, 32 and 34.

Company uses double-leg elbow amplifier to thrust-vector cold-gas jet at Mach 2; concept promises systems surpassing electronics.

P-019

Payne, Peter R.

CURVED JET FLOWS, Vol. I

DDC Report AD616395 (for contract DA44AM0238T), May, 1965

A simple equation is derived to describe curvilinear flow, and this is
then applied to various practical problems. In the case of annular jet flow,
previous theories are shown to be approximate solutions to the general equation;
the more exact solution of the report is shown to give better agreement with
experiment. The new theory is also applied to the flow of air in a curved
duct, the flow into an intake, the jet flap, and Coanda flow. Comparison with
experiment again gives good agreement. Because curvilinear flow implies diffusion,
the theory of diffusion is studied in some detail, and general theory is developed
for the total head lost in a rapid diffusion. When applied to the diffusion loss
measured in the nozzle of an annular jet, and the analogous losses in a curved
duct, the theory gives excellent agreement with experiment. The various investigations
cover fairly wide areas in subsonic aerodynamics. Thus, it has been proved
impossible to work out the applications of the theory completely for all the
cases considered. The same is true of the experimental work reported.

P-020

Payne, Peter R.

CURVED JET FLOWS, VOLUME II

DDC Report AD616357 (for Contract DA44 177AM0238T), May, 1965

The shape integral is calculated for a number of idealized asymmetric
distributions.

P-021

Pearce, Larry N; Hrubecky, Henry F.

FLOW FIELD CHARACTERISTICS IN A MODEL BI-STABLE FLUID AMPLIFIER

See Author Hrubecky, H. F.

P-022

Pearce, Larry N.; Hrubecky, Henry F.

THE EFFECT OF GEOMETRIC CHANGES UPON THE SWITCHING POINT IN A MODEL BI-STABLE FLUID
AMPLIFIER

    See Author Hrubecky, H. F.

P-023

Pedersen, John R. C.

THE FLOW OF TURBULENT INCOMPRESSIBLE TWO-DIMENSIONAL JETS OVER VENTILATED CAVITIES

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965
(other source) Paper given at the 1st Conference on Fluid Logic & Amplification
sponsored by the British Hydromechanics Research Association and the College of
Aeron. Cranfield, England, September 9-10, 1965

    A flow model is presented which leads to a simple analysis for the shape
of a curved two dimensional jet reattaching to an offset inclined wall, when the
cavity beneath the jet is ventilated. Experimental results which support the
analysis are also presented, good agreement is shown for ventilation flow rates up
to some fifteen per cent of the main jet flow. For larger relative ventilation the
momentum of the ventilating flow becomes significant but due allowance can be
made for this.

    The results are significant in forming one step towards ability to calculate
the performance of fluid logic devices.

P-024

Peoples, J A.; Scott, W. W

PHOTOELASTIC EFFECT SHOWS FLUID DEVICE PERFORMANCE

Control Engineering, July, 1965, Page 98

    At NASA Huntsville the photoelastic effect has been used successfully to
study and evaluate fluid elements. Although this effect is limited in the fluid
field to liquids by applying scaling laws-which depend on matching Reynolds number,
Acoustic Reynolds number and Stokes number-to the experimental data obtained for a
fluid of one density, the results can be interpreted for a fluid of a different
density. Thus, gaseous fluids can be analyzed indirectly by the technique.

P-025

Peracchio, Aldo

THE VORTEX-VENTURI: AN AERODYNAMIC SPEED CONTROL FOR TURBINES

Paper No. 63-WA-213, The American Society of Mechanical Engineers, 345 Eash 47th Street, New York 17, New York

This paper presents an analytical study of a purely aerodynamic speed control for turbines. A method of predicting the operating characteristics of a turbine - aerodynamic control combination is derived. Included are comparisons of theoretical and experimental operating characteristics for typical turbine - aerodynamic control combinations.

P-026

Perlmutter, M.; Deissler, R. G.

AN ANALYSIS OF THE ENERGY SEPARATION IN LAMINAR AND TURBULENT COMPRESSIBLE VORTEX FLOWS

Paper from the Lewis Flight Propulsion Laboratory NASA - Cleveland, Ohio

See Author, Deissler, R. G.

P-027

Phillips, E. R.; Lemmon, G. V.

DEVELOPMENT OF TWO PURE FLUID TIMERS

See Author Lemmon, G. V.

P-028

Phillips, E. R.; Martin, S. B.

FLUID TIMER DEVELOPMENT

See Author Martin, S. B.

P-029

Phillips, E. R. (Sperry-Rand)

JET PIPE PNEUMATIC OR GATE

U. S. Patent No. 3,191,612 dated June 29, 1965, filed August 1, 1962

This invention relates generally to the field of logical devices, particularly to a fluid device capable of performing the logical OR function.

P-030

Phillips, O. M.

A NOTE ON THE MEASUREMENT OF SOUND IN LIQUID FILLED PIPES

DDC Report AD-601102 (Hydronautics Inc., Laurel Maryland) Contract NOBS88200, January, 1963

The report is concerned with the problem of measuring the sound intensity in pipes through which turbulent liquid is flowing. Conventional methods present difficulties either in principle or interpretation, so that novel methods are sought, four such methods are suggested whose aim is to give a reliable measurement of acoustic pressure fluctuations without disturbing the sound field. They all depend on the radial pipe oscillations set up by the sound and differ in their sensitivity and ease of application.

P-031

Polter, E. M.; Zilberfarb, S. N. (Sperry Rand)

PURE FLUID VELOCITY MODULATED AMPLIFIER

U. S. Patent No. 3,182,675 dated May 11, 1965, filed, November 17, 1961

See Author, Zilberfarb, S. N.

P-032

Popov, Y. U.; Pukhnachev, Y. U., Pushkin, A.

PNEUMONICS

"Nauka i zhizn" No. 1 pages 10 to 18, 1965, Volume 1 Also, DDC Report AD-618319, July, 1965 (Unedited rough draft translation)

According to the Russian authors, inventions 124719 and 124720 recorded on April 13, 1959 marked the birth of a remarkable trend in automation, later named pneumonics. Although these early inventions were significant, they contained mechanical moving parts. As late as 1964 when an Lenin award was given to a group of men in the Institute of Automation & Telemechanics led by Professor M. A. Aizerman, this problem still remained.

P-033

Powell, Alan

AN AEROSONICS BIBLIOGRAPHY

DDC Report AD-614594 (California Institute Department of Engineering) Supplement No. 2 for Contract NONR23362, April, 1965

A bibliography of 363 references is given on the following topics: aerodynamic sound; structural excitation by flows and sound, fatigue; flow past bodies, boundary layer, fluid instability, acoustic streaming, vortical flow; jet flows and wakes, turbulence; jet noise suppression devices; propellers and rotors; rocket noise; resonance and oscillation; sonic boom and shock waves; sound propagation, scattering, transmission attenuation and reflection; structural wave dynamics; thermoacoustics; hydrodynamics.

P-034

Powell, Alan; Smith, T. J. B.

AN AEROSONICS BIBLIOGRAPHY - SUPPLEMENT No. 1

DDC Report AD600455 (University of California) Contract NONR23362 NRO62229, April, 1964

This supplementary bibliography contains available references to the open literature on aerosonics up to March, 1964 which is not included in the main volume. The scope of the bibliography has been enlarged to include references to the fluid dynamics of supersonic jet flows.

P-035

Prete, Sorro

EXPLORING FOR FUTURE HYDRAULIC REQUIREMENTS

Fluid Power Branch (SEJPF), Vehicle Power Division, September 18, 1964

   Discussion in the paper includes (1) current capabilities, (2) analysis
of powered functions to be performed on future aircraft to satisfy mission
requirements and (3) identification of future requirements for hydraulic equipment.
The discussion will consider current technical capabilities and attempt to suggest
some of the developments and state-of-art advancements in hydraulic equipment that
should take place within the next 5 years.

P-036

Priem, R. J., Heidmann, M. F.

PROPELLANT VAPORIZATION AS A DESIGN CRITERION FOR ROCKET-ENGINE COMBUSTION CHAMBERS

NASA TR-67, 1959

P-037

Prosser, Dennis W.; Fisher, Michael J.

SOME INFLUENCES OF TURBULENCE ON THE NOISE OF PROPORTIONAL FLUID AMPLIFIERS

Proceedings of the HDL Fluid Amplification Symposium, Vol. II, October, 1965

   This work represents a step toward understanding and evaluating the effects
of turbulence on the operation of proportional fluid amplifiers.

   The literature contains many relatively successful attempts to predict
analytically the mean values associated with turbulent jets, e.g., the mean
velocity field.

P-038

Pukhnackev, Y. U., Popov, Y. U., Pushkin, A.

PNEUMONICS

"Nauka i zhizn'" No. 1 pages 10-18, 1965, Volume 1, Also DDC Report AD-618319
(unedited rough draft translation).

See Author Popov, Y. U.

P-039

Pushkin, A., Popov, Y. C., Pukhnachev, Y. U.

PNEUMONICS

"Nauka i zhizn'" No.1 Pages 10-18, 1965, Vol. I, Also DDC Report AD-618319
(unedited rough draft translation)

See Author Popov, Y. U.

R-018

Raber, R. A.; Shinn, J. N. (Dr.) (General Electric Company)

FLUID AMPLIFIER APPLICATION STUDIES PHASE II

Summary Report, NASA Report No. CR-137 prepared for Contract NAS-8-5408, August, 1964

See Author, Shinn, J. N. (Dr.)

R-019

Raber, R. A., Shinn, J. N. (General Electric Company)

FLUID AMPLIFIER SYMBOLS, NOMENCLATURE AND SPECIFICATION

NASA Report CR-147 (prepared for Contract NAS 8-5408), January, 1965

This manual was prepared for the Astronionics Laboratory of the George C. Marshall Space Flight Center, NASA, to provide standardization in the No-moving-part fluid amplifier fluid. The manual is relatively concise and general to encourage its use as this new field develops; detailed standards in such a field are not considered appropriate at this early stage of development.

R-020

Rankin, T. M.; Weske, J. R. (University of Maryland)

ON THE GENERATION OF SECONDARY MOTIONS IN THE FIELD OF A VORTEX

University of Maryland, Technical Note BN-313 dated March, 1963

See Author Weske, J. R.

R-021

Rawlings, J. L. (Sperry-Rand)

FLUID COMMUTATING DEVICE

U. S. Patent No. 3,191,625 dated June 29, 1965, filed Nov. 8, 1962

This invention relates to data storage devices with novel means for repeatedly reading out stored data. More particularly, this invention provides pure fluid-operated memory elements in combination with data input means, for storing data therein and pure fluid-operated readout means for repeatedly reading out the stored data.

R-022

Reader, T. D.; Gluskin, R. S.; Jacoby, M.

A FLUID-LOGIC DIGITAL COMPUTER

   See Author Gluskin, R. S.

R-023

Reader, T. D.; Cargill, N. A. (Sperry-Rand)

ELECTRO-SONIC FLUID AMPLIFIER

U. S. Patent No. 3,144,037 dated August 11, 1964

   See Author Cargill, N. A.

R-024

Reader, T.; Shook, T. A.; Chen, T. F.

FLUID AMPLIFICATION 12. BINARY COUNTER DESIGN

DDC Report AD617699 (Univac Division Sperry Rand Corp. For Contract DA49 186 AMC34X)
November, 1964

   See Author Shook, T. A.

R-025

Reader, T. D. (Sperry Rand)

PERFORATING MECHANISM

U. S. Patent 3,176, 571 dated April 6, 1965, filed June 8, 1962

   The punching device according to this invention comprises a bistable
fluid amplifier and a punching mechanism proper. The fluid amplifier serves
to selectively direct a fluid pulse into a nozzle. Adjacent the nozzle there is
located a dish like body carrying the punch. Upon the application of a signal,
the fluid amplifier directs its power stream into the nozzle.

R-026

Reader, T. D. (Sperry Rand)

PNEUMATIC CLOCK

U. S. Patent No. 3,159,168 dated December 1, 1964, filed February 16, 1962

This invention relates to a pure fluid device which is capable of generating pulses at predetermined intervals, and more particularly to a clock pulse generator whose mode of operation may be either symmetrical or asymmetrical without requiring any change in the physical dimensions of the device.

R-027

Reader, T. D. (Sperry Rand)

PULSE GENERATOR

U. S. Patent No. 3,159,169 dated December 1, 1964, filed September 4, 1962

This invention relates to pure fluid operated pulse generators, more particularly, the present invention relates to fluid pulse generators of the type having a stable state and an unstable state with means of producing output signals indicating the state of the pulse generator and further means for producing an output signal each time the pulse generator switches from one state to the other. An object of this invention is to provide a monostable fluid operated pulse generator having means for controlling the length of time during which it remains in its unstable state.

R-028

Reader, T. D., Gehring, A. J., Jr.; Jacoby, M. (Sperry Rand)

PURE FLUID COMPUTER

U. S. Patent No. 3,190,554 dated June 22, 1965, filed June 19, 1963

See Author Gehring, A. J. (Jr.)

R-029

Reader, T. D.; Gluskin, R. S.; Jacoby, M.

THE UNIVAC FLUID COMPUTER

See Author Gluskin, R. S.

R-030

Reeves, D.; Inglis, M. E.; Airey, L. (National Gas Turbine Establishment, U. K.)

THE FLUID OSCILLATOR AS A TEMPERATURE SENSOR

Paper given at the First Conference on Fluid Logic and Amplification sponsored by the British Hydromechanics Research Association and the College of Aeron. Cranfield, England, September 9-10, 1965

R-031

Reid, K. N., Jr. (Oklahoma State University)

AN EXPERIMENTAL STUDY OF THE STATIC INTERACTION OF AN AXISYMMETRICAL FLUID JET AND A SINGLE RECEIVER-DIFFUSER

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. IV, October, 1965

Results are presented from studies of several fundamental hydrodynamic processes typically encountered in fluid-jet modulator systems. Measured velocity profiles are presented for the flow establishment, transition, and established flow regions of an axisymmetrical, free, submerged, turbulent air jet. Improved velocity profile correlation and prediction techniques are suggested.

Studies have been conducted to elucidate the details of internal diffusion of the nonuniform stream resulting from direct impingement of a submerged jet on the mouth of a receiver-diffuser system comprised of a constant-area mixing section followed by an area-change diffuser. Results are presented from measurements of transverse profiles of the axial velocity and wall static pressure taken at various stations along the receiver-diffuser system. Velocity profile uniformity factor correlations are presented which permit rapid computation of the static pressure increase or decrease as a function of length of the constant-area mixing section. Judgements and decisions may be made as the the "optimum" length of the constant-area mixing section of a receiver-diffuser in order to maximize over-all diffusion efficiency.

R-032

Reid, K. N. Jr., (Oklahoma State University)

DYNAMIC INTERACTION OF A FLUID JET AND A RECIEVER LOAD SYSTEM

One important class of jet-receiver-load dynamic interaction problems has been studied in detail. It is demonstrated that a static or dynamic instability may exist as a result of jet-receiver-load interaction. Methods are presented for characterizing the jet-receiver interaction region both statically and dynamically. Typical static pressure-flow characteristics for the interaction region are presented which exhibit an S-shaped character for certain geometrical configurations. It is demonstrated that the S-shaped characteristic leads to a static instability for high impedance loads. Analytical, graphical, and numberical computation techniques are presented which permit rapid and accurate prediction of relative and absolute stability for a jet-receiver-load system. Experimental measurements show good correlation with predictions of system limit cycle frequencies and amplitudes.

R-033

Reilly, R. J. (Minneapolis Honeywell)

ALL-FLUID DEVICES AND THEIR APPLICATION TO GAS TURBINE CONTROLS

Discussion of the basic operating principles of fluid sensing and control devices. A closed-loop gas-turbine control system using these devices has been implemented in breadboard form. It is noted that, since this control concept does not rely on prescheduled control parameters, complexity is reduced. The feasibility of this control concept has been demonstrated by the operation of a G. E. J-35 engine on fluid control between idle and 100% power settings.

R-034

Reilly, R. J.; Moynihau, F. A.

DEFLECTION & RELATIVE FLOW OF THREE INTERACTING JETS

See Author Moynihau, F. A.

R-035

Reilly, R. J. (Minneapolis-Honeywell)

PURE FLUID AMPLIFIER

U. S. Patent No. 3,170,476 dated February 23, 1965, filed August 22, 1962

This invention is directed to an improved type of pure fluid amplifier and the improvement is in the positioning of the fluid control ports to provide control streams that are more effective in their operation.

R-036

Republic Aviation Corp.

RESEARCH INVESTIGATION OF HYDRAULIC PULSATION CONCEPTS

DDC Report AD-607618, Prepared for Contract AF33(657)10622, See also AD600-663, October, 1964

This final report covers a program during which Republic made a research investigation of the technical feasibility of the transmission and utilization of hydraulic power through the use of pulsating pressure or pulsating flow concepts. It was concluded that the pulsating flow means were suitable for power transmission, whereas pulsating might be adapted for signal transmission. The type of system currently in greatest use in aerospace vehicles is the constant pressure flow demand system that utilizes a pressure-compensated variable delivery pump. Republic believes that an adaptation of this system to the requirements of a pulsating system will produce the most desirable means of control from the standpoints of efficiency, simplicity, and reliability. Our major efforts have therefore been concerned with the design of such adaptation. The Research Investigation was carried on by two methods: (1) The design effort, and (2) the analytical method. The laboratory effort was limited to relatively simple experiments intended to verify or facilitate analytic results. The system analysis was augmented and verified by data derived from a miniaturized pulsating hydraulic system.

R-037

Richards, E. F.; Graber, S. D. (Martin/Orlando)

TRANSITION TO TURBULENCE AND WALL ATTACHMENT OF MINIATURE JETS

A study of transition to turbulence in nozzles has been undertaken with useful predictions resulting. Both theoretical and experimental work in transition to turbulence in jets is needed. The effects of aspect ratio as well as Reynolds number needs to be investigated. The birefringent visualization technique appears to be well adopted to such experimentation. It has been possible to predict the geometrical requirements for bi-stability in symmetrical elements operating with subsonic and perfectly expanded sonic jets. Limited verification of the theory has been completed in the incompressible case. All trends appear to be well represented.

R-038

Ringwall, C. G. (General Electric Company)

INVESTIGATION OF WATER AND STEAM AS THE WORKING FLUID IN A FLUID AMPLIFIER SPEED GOVERNOR FOR TURBINE GENERATOR SETS

R-039

Ringwall, C. G.; Shinn, J. W.; Boothe, W. A.

NEW FLUID AMPLIFIER TECHNIQUES FOR SPEED CONTROLS

See Author Boothe, W. A.

R-040

Riordan, H. E. (General Precision, Inc.)

PNEUMATIC COMPUTER ELEMENT AND CIRCUITS

U. S. Patent No. 3,151,623 dated October 6, 1964, filed November 28, 1962

This invention relates to a pneumatic computer element and to pneumatic computer circuits, and more particularly to a pneumatic computer element having a number of stable operational positions, and to pneumatic computing circuits performing digital computation functions.

R-041

Riordan, H. E. (General Precision, Inc.)

PNEUMATIC DIODE

U. S. Patent No. 3,068,880 dated December 18, 1962, filed December 28, 1961

This invention relates to diodes and more particularly to a pneumatic diode that can be used in the pneumatic instrumentation of digital computing functions.

R-042

Rivard, J. G.; Walberer, J. C. (Bendix Corp.)

A FLUID STATE VORTEX HYDRAULIC SERVOVALVE

Paper presented at the 21st National Conference on Fluid Power, Chicago, Illinois, October 22, 1965

The vortex hydraulic servovalve concept discribed in this paper can provide four-way valve operation with pressure flow characteristics similar to those achieved using a four-way spool type valve. The vortex valve has demonstrated a 10 to 1 flow modulation range. The unique flow pickoff provides the capability for driving a double acting actuator, only using two vortex elements. It also provides flexibility in adjusting the flow gain. The vortex valve does have a quiescent breakage higher than that realized from mechanical valves. This is inherent in a device which operates with dynamic fluid flow principles. The performance from $0°F$ to $100°F$ on MIL - O - 5606 has been evaluated with no significant change in gain or flow modulation range.

R-043

Rivest, E. L.; Wood, D. E.; Dodson, G. C. (General Electric Company)

SIGNAL PROCESSING AND WAVEFORM PATTERN RECOGNITION FOR -- ANALYSIS OF SIGNAL
ORIGINS, INSTRUMENTATION AND AUTOMATION

G. E. TIS Report 65-C-041 dated September 14, 1965

See Author, Wood, D. E.

R-044

Roberts, W. J.

EXPERIMENTAL DYNAMIC RESPONSE OF FLUID LINES

MS Thesis, Purdue University, 1963

R-045

Rodely, A. E.; White, D. F.; Chanaud, R. C.

A DIGITAL FLOWMETER WITHOUT MOVING PARTS (American Radiator & Standard Sanitary
Corp)

ASME Paper 65WA/FM-6 presented at the Winter Annual Meeting, Chicago, November
7-11, 1965

The origins and development of a new type of volumetric flowmeter, which has
been given the name Swirlmeter[1], are described. The operation of the meter depends
upon a unique hydrodynamic oscillatory motion which is generated in a simple
geometrical arrangement containing no moving parts. The metering system is inherently
digital, and test data have shown the meter characteristic to be linear over a wide
Reynolds number range. A description of a field trial of the complete flowmeter
system is given and calibration data taken with this system at an independent
calibration facility are presented.

[1]Trademark of American Radiator and Standard Sanitary Corp.

R-046

Roffman, Gary

ABSOLUTE PRESSURE RATIO MEASUREMENT FOR JET ENGINE CONTROL

R-RCA-63-17, April 29, 1963

A no moving parts absolute pressure ratio measuring device using a vortex is discussed and analyzed qualitatively. Also described is a means of measuring absolute pressure ratios by a shock wave position in a nozzle.

R-047

Roffman, G.; Katz, S.

FLUERIC OPERATION ON PRESSURE SIGNALS

See Author Katz, S.

R-048

Roffman, Gary L.; Katz, Silas

PREDICTING CLOSED LOOP STABILITY OF FLUID AMPLIFIERS FROM FREQUENCY RESPONSE MEASUREMENTS

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965

Open loop frequency response measurements were made on a loaded fluid amplifier. The measurements showed frequency response resonance peaks up to 8000 cps. Using the Nyquist criteria, the stability of the closed loop system is predicted. The oscillation frequency of unstable systems is also discussed.

R-049

Roffman, G L. (Harry Diamond Lab)

STAGING OF CLOSED PROPORTIONAL FLUID AMPLIFIERS

A method of staging a closed proportional fluid amplifier for large flow gain is discussed. The amplifier, of which all stages are similar, was designed by considering momentum and continuity of the fluid between stages. The gain of each stage, which is equal to the ratio of the power nozzle area of a stage to the power nozzle area of the previous stage, is calculated to be 5.7.

R-050

Romanenko, P. N.; Leont'EV, A. I., Oblivin, A. N.

A STUDY OF RESISTANCE AND HEAT EXCHANGE IN THE MOTION OF HEATED AIR IN DIFFUSORS AND MIXERS

Experimental studies were made of resistance and heatexchange in a turbulent stream of heated air in an axisymmetric diffusor with 8 degree 4 min angle of opening, and in an axisymmetric mixer with 8 degrees angle of opening. The tests run embraced a range of numbers RE = (1,688 to 8.45) .100000. The temperature of the walls of the ducts, which were cooled by water, varied from 286 to 320 K; the temperature of the air stream varied from 425 to 623 degrees. M numbers were $\le$ OR = 0.5.

R-051

Rose, R. K.; Bowlin, R. C. (General Electric Company)

DYNAMIC INTERACTION ANALYSIS AND COMPUTER MODEL LEM REACTION CONTROL PROPULSION SYSTEM VOLUME I TECHNICAL DISCUSSION

R-052

Rose, R. K. (General Electric Co.)

FLUID AMPLIFIER DIGITAL INTEGRATOR

NASA Report prepared by the G. E Co. for Contract NAS8-5408, March, 1965

The digital integrator is a basic building block in digital computation and control systems which can be used to solve non-linear differential equations, multiply, and generate functions. Integration can be performed with respect to time or any other variable. The fluid amplifier implementation of the applicable digital logic equations is presented. Thirty-seven OR-NOR, flip-flop, and digital amplifier elements were assembled into a circuit comprising an adder, shift register and complementer. The experimental digital integrator used serial implementation of 5 bit words and was operated at a nominal 100 cps clock frequency. Experimental results are presented which show the integrator's response to a step input as well as all of the detailed arithmetic operations within the integrator. An application showing the interconnection of integrators into a digital-differential-analyzer navigation system is included.

R-053

Rouleau, W. T.; Young F. J.; Augrist, S. W; Osterle, J. F.

UNCONVENTIONAL METHODS FOR INFLUENCING FLUID FLOW

See Author Osterle, J. F.

R-054

Rudle, M. A.; Wiesner, H. J.; Stuttgart, T. H. (Germany)

FLUID DEVICES FOR MACHINE CONTROLS

Paper given at the First Conference on Fluid Logic and Amplification sponsored by the British Hydromechanics Research Association and College of Aeron, Cranfield, England, September 9-10, 1965

R-055

Rupe, Jack H.

ON THE DYNAMIC CHARACTERISTICS OF FREE-LIQUID JETS AND A PARTIAL CORRELATION
WITH ORIFICE GEOMETRY

Technical Report No. 32-207, Jet Propulsion Laboratory, California Institute of
Technology, Pasadena, California, January 15, 1962

A technique for evaluating the dynamic characteristics of free-liquid jets
on a comparative basis is presented. This method consists of determining the
pressure distribution produced by the perpendicular impingement of a jet upon a
flat plate and using these data for comparing and categorizing jets with unknown
properties in terms of similar data produced by jets having known characteristics
i.e., with jets produced by fully developed turbulent flow, fully developed
laminar flow, and a jet having a near-uniform velocity profile.

The visual characteristics, as well as both the mean and the fluctuating
pressure distributions, are presented for these three reference configurations and
for a number of jets produced by orifices having varying length-diameter ratios,
combined with varying degrees of surface roughness in the initial five diameters
of straight bore.

R-056

Rutherford, D. E.

FLUID DYNAMICS

Book published by Interscience Publishers, Inc., New York, 1959

R-057

Ryti, M.

PULSATION IN THE AIR INTAKE SYSTEMS OF TURBOCHARGED DIESEL ENGINES

The Brown Boveri Review, Vol. 52, 1965

Pulsation in the air piping of turbocharged diesel engines is generally
undesired because it can impair the stable operation of the compressor. A method
of calculation is described which, with a minimum of outlay, can be used to
determine the pulsation characteristics of an arbitrary piping system. The solutions
are depicted with the aid of the conception of impedance. Some boundary conditions
are formulated and the excitation by the suction of the engine dealt with. The
stable operating ranges are determined for a simplified model of the compressor.
The examples quoted demonstrate the close agreement between the calculation and
measurements.

S-039

Saghafi, H. T. (IBM, Bethesda, Maryland)

STATIC DESIGN OF PNEUMATIC LOGIC CIRCUITS

This paper describes the static design of pneumatic logic circuits using jet amplifiers. The design approach is presented in the graphical form for better visualization of circuit operations. Basically, we are concerned with a generalized logic circuit which is modified to build resistor and diode AND and OR blocks. Initially, two algebraic circuit equations are derived for the output network of this generalized block. Then, the existence of a focus point for the switching points (a useful property of the input network) is demonstrated. Finally, the graphical design approach of several resistor and diode logic circuits is presented.

The result of the analysis is the qualitative determination of an over-all relationship between fan-in, instability distance, switch points, and input impedance of the attachment amplifier. From these relationships a theoretically ideal input characteristic was evolved which would result in circuit design flexibility as well as maximum fan-in for a given instability region.

S-040

Samet, F.

BINARY FLIP-FLOP ELEMENT FOR PNEUMATIC DIGITAL COMPUTER

The primary feature of this invention is that a single bi-stable element actuated by negative pulses or openings is utilized as a flip-flop. It is directed primarily to computer elements used in hot gas systems, in which gas at high temperatures and relatively high pressures is utilized. Features are: The computer element is relatively small, compact, and in which the fit between the ball or piston and the cyclinder in which it is mounted, while fairly close, still provides some clearance so that a certain amount of leakage is provided past the piston or reciprocative ball within the cyclinder in which the ball or piston is operated.

S-041

Sarpkaya, T. (University of Nebraska)

A BISTABLE VORTEX OSCILLATOR

Description of a bistable vortex oscillator which operates with the "push-pull" provided by pressure fluctuation caused by the alternate shedding of vortices behind a circular cylinder. The "push-pull" is applied alternately at the two control ports of a bi-stable amplifier.

S-042

Sarpkaya, Turgut

A THEORETICAL & EXPERIMENTAL INVESTIGATION OF THE VORTEX-SINK ANGULAR RATE SENSOR

This paper describes the characteristics of flow of a viscous fluid between two rotating coaxial disks separated by a porous cylindrical wall. The sensitivity of the device to rotational motion has been determined for various flow rates, angular velocities, and types of pickoffs. The viscous efficiency of the sensor has been determined theoretically and compared with that obtained experimentally. It is found that the device as well as the pickoff may be designed for a given range of operation and maximum rate detection through a combination of theoretical and experimental studies.

S-043

Sarpkaya, T. (University of Nebraska)

CHARACTERISTICS OF COUNTER-VORTEX OSCILLATORS

The characteristics of the vortex motion created by two vortices rotating in opposite directions in an axially symmetrical vortex tube are investigated. Various geometrically similar units were constructed and tested with air as the working fluid. The median pressures, the amplitude and the frequency of the pressure oscillations at the two vortex chambers were determined. It is found that only the unique combinations of pressure at the two vortex chambers produce oscillations of constant amplitude and frequency. There appears to be a linear relationship between the two pressures.

S-043 (Continued)

Sarpkaya, T.

CHARACTERISTICS OF COUNTER-VORTEX OSCILLATORS

The initial vortex motion, while irrotational immediately after entry into
the vortex tube, does not stay irrotational, but transforms itself partly to
rotational flow as it proceeds along the connecting tube. The change from one
flow to the other is due to viscosity. The rotational flow has the lesser amount
of useful kinetic energy. The amplitude of the pressure oscillations increases with
decreasing lengths of the connecting tube while the inverse is true for the
frequency. The characteristics of the counter-vortex motion are strongly dependent
on the ratio of the tangential velocity to the axial velocity at the jet origin.
When this ratio is sufficiently large the axial velocity reverses its direction
near the jet axis.

S-044

Sarpkaya, Turgut (University of Nebraska)

CHARACTERISTICS OF A VORTEX DEVICE & THE VORTEX-BREAKDOWN PHENOMENON

Proceedings of the HDL Fluid Amplification Symposium, Vol. II, October, 1965

The results of an investigation of the forced and periodic breakdown of a
confined vortex by another vortex rotating in the opposite direction are presented.
The vortex tube consists of two chambers connected by a short conduit through
streamlined transitions. The upstream end is closed by a plain wall and a circular
orifice is provided at the downstream end. The swirling flow and the breaker-vortex
are generated by introducing varying proportions of air or water through tangential
ports located near the upstream and downstream walls of the unit. The cases of
single-breakdown and periodic-breakdown are explored and typical data are presented
for each case.

S-045

Sarpkaya, Turgut (University of Nebraska)

STEADY & TRANSIENT BEHAVIOR OF A BISTABLE AMPLIFIER WITH A LATCHING VORTEX

    Reported herein is an investigation of the steady and transient behavior of an unvented, cusped, bistable amplifier. Experiments were conducted with air and water as the working fluids. The evolution of the latching vortex and the variation of pressure at about 15 critical points in the interaction region were studied for two types of switching: (a) by restricting the on-side load port, and (b) by applying a signal to the on-side control port. Each type of switching was investigated under quasi-steady and transient conditions. The pressure perturbations in the interaction region, evolution of pressure in the attachment bubble, formation of vortices at the two sides of the cusp, the differences between the transient and quasi-state switching, and the propagation of shock waves are discussed with the help of normalized curves and motion pictures.

S-046

Savino, Joseph M.; Keshock, Edward, G.

EXPERIMENTAL PROFILES OF VELOCITY COMPONENTS & RADICAL PRESSURE DISTRIBUTIONS IN A VORTEX CONTAINED IN A SHORT CYLINDRICAL CHAMBER

    The chamber was formed by two 11.72-inch-diameter disks spaced 1.25 inches apart. A high swirl was imparted to the fluid (air) as it entered the chamber through 48 tangentially alined vanes. A 2-inch-diameter tube at the center of one disk served as the exhaust port. Static pressure and the profiles of the radial and tangential velocity components were measured at 8 radial stations. All the radial inflow took place close to the disk surfaces, while a slow outward flow existed in midchannel. The tangential velocities were used to predict the static pressures which agreed well with the measured values.

S-047

Schaffer, R. R.; Akmenkalus, I. G.; Pasternak, E.

PNEUMATIC TO ELECTRIC TRANSDUCERS

    See Author Akmenkalus, I. G.

S-048

Schrepil, D.; Toepfer, H.; Schwarz, A.

UNIVERSAL ASSEMBLY OF PREFABRICATED MACHINE PARTS FOR PNEUMATIC GUIDANCE CONTROL

Report AD-608416 (Foreign Tech. Div. Air Force Systems Command WP AFB)

   See Author Toepfer, H.

S-049

Schroeder, E. F. (Cornell Aeronautical Lab. Inc.)

EXPERIMENTAL INVESTIGATION OF THE PERFORMANCE CHARACTERISTICS OF A FLOW-INSTABILITY SENSING DEVICE

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. IV, October, 1965

   Research performed for the U. S. Air Force Aero-Propulsion Laboratory
(Contract AF33(615)-1240) included an investigation of fluid state devices potentially
capable of sensing the flow instabilities characteristic of rotating stall in
axial-flow jet-engine compressors. The sensing system investigated consists of
three interrelated components: (1) control circuit, (2) fluid amplifier, and
(3) load. Static and dynamic tests were performed with several control circuit
configurations and a range of bistable amplifier geometric parameters defining the
mixing region. The input signal, consisting of periodic pressure pulses applied
to a total pressure probe, is modified by the control circuit transmission
characteristics (filtering, time delay, reflections, etc.). This modified
signal is applied at the fluid amplifier control ports to produce a switching
action. The resulting output, which consists of alternating pressure pulses from
the two receiver ports, could be used with a signal processing device to initiate
an appropriate compressor control action. Test results indicate that switching is
possible with some configurations over the frequency range of 50-1000 cps with input
pressure pulses of magnitude less than .05 times the absolute nozzle pressure, at
a nozzle pressure ratio down to .70, using a power nozzle area of .010 sq. in. A
description of the test equipment, a discussion of the sensor performance, and an
evaluation of the test results are given in the paper.

S-050

Schuder, Charles B. and Blunck, George C.

THE DRIVING POINT IMPEDANCE OF FLUID PROCESS LINES

   See Author, Blunck, George C.

S-051

Schumann, B. A.; Walker, G. K.

A DISCUSSION OF NESS'S ANALYSIS FOR A TURBULENT BOUNDARY LAYER WITH MASS ADDITION

DDC Report AD600627 (G. E. Co. MSD Report R61SD49) Contract AF04(647)715

    See Author Walker, G. K.

S-052

Schumann, B. A.; Walker, G. K.

THE GROWTH OF TURBULENT BOUNDARY LAYERS

DDC Report AD-601503 (G. E. Co. Missile & Space Division for Contract AF04(645)24,) July, 1964

    See Author Walker, G. K.

S-053

Schuarz, K. W.; Springett, B. E.; Donnelly, R. J.

MODES OF INSTABILITY IN SPIRAL FLOW BETWEEN ROTATING CYLINDERS.

Journal of Fluid Mechanics, 1964, Vol. 20, Part 2 Pages 281-289

    A study of the stability of flow between concentric cylinders, with the inner one rotating, distinguished three kinds of instabilities: the familiar axisymmetric mode, and azimuthal mode with the predicted exp i (θwt) angular dependence, and a completely non-symmetric instability which apparently arises from the interaction of the other two. The effect of small axial flow upon all of these modes was to give an approximately parabolic dependence of the critical Taylor number on the axial flow rate. In the case of the axisymmetric mode, agreement with the theory of Krueger and Di Prima (1964) was found to be excellent.

S-054

Schwarz, A.; Toepfer, H.; Schrepel, D.

UNIVERSAL ASSEMBLY OF PREFABRICATED MACHINE PARTS FOR PNEUMATIC GUIDANCE CONTROL

Report AD-608461 (Foreign Tech. Div. Air Force Systems Command WPAFB)

    See Author Toepfer, H.

S-055

Schwiderski, E. W.; Lugt, H. J.; Uginciu, S. P.

AXISYMMETRIC VISCOUS FLUID MOTIONS AROUND CONICAL SURFACES

DDC Report AD600962 (Naval Weapons Lab.), May, 1964

    The introduction of complex Navier-Stokes equations shows that steady
axisymmetric motions of viscous incompressible fluids around conical surfaces can
be expressed in terms of the corresponding general solution of the Stokes equations
of slow motions. The latter integration is accomplished with the aid of slow-motion
eigenfunctions with integral eigenvalues for infinite plates and semi-infinite
needles and with generally complex eigenvalues for cones and conical corners. The
eigenvalues and eigenmotions obtained resemble the corresponding eigenvalues and
eigenmotions of analogous flows-past dihedral angles. In particular, the existance
of critical and branching eigenvalues reveals that laminar flows past conical
surfaces depend on the cone angle in a nonanalytic manner. The investigations include
a note on diffusor and jet flows.

S-056

Scott, W. W.

PHOTOELASTIC EFFECT SHOWS FLUID DEVICE PERFORMANCE

Control Engineering, July, 1965, Page 98

    See Author Peoples, J. A.

S-057

Scudder, Kenneth, R.

INSTRUMENTATION

DDC Report AD-613711 (Harry Diamond Labs Report), 1963

This paper reviews the various types of instrumentation and the tools useful in measuring and detecting the phenomena occurring in fluid amplification devices. Topics include: Pressure measurement, flow-velocity measurements, frequency measurement, recording and calibration.

S-058

Scudder, Kenneth R.

SOME SPECIAL CIRCUITRY

DDC Report AD613712 (Harry Diamond Lab Report), 1964

There are a number of interesting applications or devices where fluid elements or fluid circuits with no (or almost no) moving parts are used. Some of these applications or devices not covered elsewhere are discussed in order to give a general idea of the range of application of the fluid amplification techniques, along with some approaches for solving certain fluid problems. The development of special fluid circuitry for fluid logic devices and fluid computing functions is dealt with in some detail. The objectives sought with fluid interaction devices are: To simplify the equipment, to make the entire system compatible throughout, to increase reliability, to reduce cost, to reduce the device susceptibility, to the environment such as radiation, temperature, shock, vibration, etc., to facilitate fabrication, to avoid wear, to take advantage of an economical working media, or any number of other special reasons.

S-059

Seaton, W. J. (Sperry-Rand)

BISTABLE FLUID DEVICE

U. S. Patent No. 3,148,692 dated September 15, 1964, filed September 17, 1962

This invention relates to a fluid operated device which is stable in two modes of operation without requiring moving parts.

S-060

Seubold, J. G. (Hughes Aircraft Co.)

TURBULENT MIXING OF A TWO DIMENSIONAL FREE JET.*

The two different sets of equations derived by Tollmein and Goertler for the
two-dimensional compressible free jet mixing layer, using the similarity assumption
have been programed for the IBM 7044, and solutions to a wide variety of problems
have been carried out. These solutions demonstrate the validity and accuracy of
the method, illustrate the effect of changes in Prandtl number and other parameters
compare the results of the Tollmein and Goertler methods, and provide analytical
curves used for evaluating the spreading parameter. Boundary layer temperature,
velocity, and concentration profiles calculated for a number of cold and hot air jets
and for rocket engines under various conditions are presented. The most interesting
feature of the boundary layer of a rocket engine is the continued high boundary
layer temperature as the altitude increases. Although the gas makes an adiabatic
expansion to low pressure and temperature, much of the kinetic energy is recovered
and converted back to thermal energy in the boundary layer. A second result of this
boundary layer study is the discovery of the universal nature of the normalized
velocity profiles, which were found to depend only on the stagnation temperature of
the jet.

S-061

Severson, A. M. (Minneapolis-Honeywell)

CONTROLLED FLUID UNIT

This invention is directed generally to a fluid flow control system wherein a
control device having no moving parts regulates the flow of fluids through
associated loads in a manner to provide for only part of the fluid to flow through
the load at each control point.

S-062

Severson, A. M. (Minneapolis-Honeywell)

FLUID OPERATED PUMP

U. S. Patent No. 3,176,920 dated April 6, 1965, filed May 26, 1961

This invention is directed to a unique type of pressure operated pump and more particularly is directed to a diaphragm sealed pump that is operated through the oscillations of a fluid amplifier in a fluid control system.

S-063

Sewell, Clinton; Blanchard, D. L.

PURE FLUID TECHNOLOGY & POSSIBLE ORDNANCE APPLICATIONS

See Author Blanchard, D. L.

S-064

Shapiro, A. H.

INVESTIGATION ON THE BOUNDARY LAYER IN A CORNER

DDC Report AD-614689 (MIT Report on Contract DA190200 RD4538),March, 1963

Abstracts are presented of reports on the following topics: Three-dimensional laminar boundary layer along a corner; fully developed turbulent flow in straight rectangular ducts - secondary flow, its cause and effect on the primary flow; electrochemiluminescence; thrust of a small orifice at low Reynolds numbers; and formation of bubbles in a uniformly fluidized bed.

S-065

Sharp, R.; Bath, M. (National Engineering Laboratory, U. K.)

NON-CONTACT MEASUREMENT FOR MACHINE TOOL CONTROL

Paper given at the First Conference on Fluid Logic and Amplification sponsored by the British Hydromechanics Research Association and College of Aeron. Cranfield, England, September 9-10, 1965

S-066

Shearer, J. L. (Pennsylvania State University)

CANDID LOOK AT FLUID CONTROL SYSTEMS - 1965

Proceedings of the 1965 Joint Automatic Control Conference (6) held at Rensselaer
Polytechnic Institute, Troy, New York, June 22-25, 1965, 1AA-A65-28815

The field of fluid amplification and the development of so-called "all fluid
control systems" has reawakened a strong interest in research, development, design
and analysis of non-electrical low power level, signal-type hydraulic and pneumatic
systems and circuits. Although, it is not yet evident that fluid systems will
ever become as widely used as electric and electronic systems, the advent of fluid
jet modulators, sometimes referred to as fluid state devices, to perform switching
operations and/or to produce amplification has led to a widening of the sphere of
application of fluid control techniques.

S-067

Shearer, J. L.; Lowen, J.

THE ROLE OF NEW DEVELOPMENT IN FLUID POWER CONTROL FOR AEROSPACE SYSTEMS

See Author Lowen, J.

S-068

Sheeran, William J.; Dosawjh, Darshan S.

INVESTIGATIONS OF INTERACTING UNDEREXPANDED JET FLOWS

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-28, 1964

Some further experiments were performed with transversely impinging two-
dimensional underexpanded jet flows as an extension of the work reported at the
Diamond Ordnance Fuze Laboratories Fluid Amplification Symposium held in October
1962. The previous observations on the radical changes in shock structure and
recovery stagnation pressure distribution in a highly underexpanded jet flow due
to the transverse impingement of a relatively low pressure jet flow were investigated
further. From pitot pressure traverses and shadowgraphs it was determined that
while an earlier proposed interaction model can be used to explain the pitot
pressure distributions, certain new observations suggest a possible modification
which is discussed in the paper.

S-069

Sher, Neil C.

JET ATTACHMENT AND SWITCHING IN BISTABLE FLUID AMPLIFIERS

ASME Paper No. 64-FE-19 for presentation at the Fluids Engineering Conference, Philadelphia, Pennsylvania, May 18-21, 1964

The extended theory of Bourque and Newman is useful in predicting jet attachment distances in bistable amplifiers if the parameter σ is adjusted according to the geometry. The theory adequately accounts for control flow effects so long as the contribution from momentum exchange is small.

The jet attachment distance was found to be insensitive to the presence of an opposite, symmetric wall, to divider position, and to outlet loading for the configurations tested. However, the amplifier switching characteristics are sensitive to all of these variables.

An empirical relationship was developed which is useful in predicting the input-flow-gain characteristics of fluid flip/flops - at least for slot aspect ratios near 4.

S-070

Shinn, N. N.; Boothe, W. A.

CONNECTING ELEMENTS INTO CIRCUITS AND SYSTEMS

See Author Boothe, W. A.

S-071 Shinn, J. N. (Dr.)

FLUID AMPLIFIERS

Paper presented at the 17th Annual Symposium of the ISA (New Jersey and New York Sections) held at Newark, New Jersey, April 6, 1965

Fluid amplifiers are a new class of control devices with unique capabilities. They perform logic, amplification and control functions by using fluid flow and interaction as the basic operating principles. Some fluid amplifier concepts utilize moving parts but only the no-moving parts variety are discussed in this paper. Practically any fluid can be used, either gases or liquid and often a particular element will operate equally well on both.

S-072

Shinn, J. N. (Dr.); Raber, R. A. (General Electric Co.)

FLUID AMPLIFIER APPLICATION STUDIES PHASE II SUMMARY REPORT

This report summarizes the work performed under Phase II of "Research and
Development-Fluid Amplifiers and Logic" for NASA George C. Marshall Space Flight
Center under contract NAS-8-5408.

The Phase II work consisted of studies to determine which applications of
fluid amplifiers would be advantageous to NASA. It has been concluded that the
best applications for further study are 1) replacement of electronic amplifiers and
networks of gas servos for engine actuation, and 2) a digital integrator which
forms the fundamental building block for nearly all digital computation and control.
Advantages of using fluid amplifiers for these applications are primarily environmental
tolerance and the potential of higher reliability. A brief comparison of fluid
amplifier and electronic reliability is included in this report.

S-073

Shinn, Dr. Jeffery N. (Research and Development Center, G. E.) Schenectady, N. Y.

FLUID AMPLIFIERS MOVE FAST

Fluid amplifiers are a recent development which can perform logic and control
functions using gas or liquids as the operating medium. Digital and analog
device concepts are presented and typical performance characteristics are
discussed. Typical circuits are included and a brief description of some
industrial and military applications is presented.

S-074

Shinn, J. N. (General Electric Co.)

FLUID AMPLIFIER STATE-OF-THE-ART (Volume I)

NASA Report CR-101 prepared for George C. Marshall S. F. C. Under Contract NAS-8-5408, September 3, 1963

This report surveys the current state-of-the-art of fluid amplifiers including both theoretical and practical aspects of devices having no mechanical moving parts. It is based on a complete review of the published literature (with an extensive bibliography), information obtained from 20.organizations involved in fluid amplifier development, and work performed by the General Electric Company. Specific areas covered are design techniques both analytical and experimental; typical elements and assemblies; applications, both now in use and contemplated; fabrication techniques; and instrumentation. The report concludes that, although simple applications are now being made, the fluid amplifier field is still in the early development stage. There continues to be a basis for optimism for space applications requiring extreme environmental tolerance, long life, or the elimination of fluid system interfaces specialized military and commercial applications also look promising. Work now under way should provide a better understanding of the design of devices and increase the number of useful applications.

S-075

Shinn, J. N.; Raber, R. A. (General Electric Company)

FLUID AMPLIFIER SYMBOLS, NOMENCLATURE AND SPECIFICATIONS

NASA Report CR-147 (Prepared for contract NAS8-5408), January, 1965

See Author Raber, R. A.

S-076

Shinn, J. N.; Boothe, W. A.; Ringwall, C. G.

NEW FLUID AMPLIFIER TECHNIQUES FOR SPEED CONTROLS

See Author Boothe, W. A.

S-077

Shinn, Jeffrey N.

NO MOVING PARTS NEEDED!
    FLUID AMPLIFIERS PERFORM ELECTRONIC-LIKE FUNCTIONS

Based on report to SAE Subcommittee A-6C

    Fluid elements and components are being used to perform switching, amplification,
logic, and computation functions much like electronic devices . . . but with
NO MOVING PARTS.

S-078

Shinn, J. N.; Underwood, F. A.; Hahn, G. J.; (General Electric Company)

PROCEDURE FOR OBTAINING FLUID AMPLIFIER RELIABILITY DATA

NASA Report prepared by the General Electric Company for Contract NAS 8-5408,
November, 1965

    This report summarizes the work performed to develop initial procedures by
which an assessment of fluid amplifier reliability may be made. A specific test
directed toward evaluating the reliability of fluid amplifiers and a generalized
failure report form have been developed. Recommendations have been submitted
for procedural improvements and expanded scope, to better understand the physics of
fluid amplifier failures.

S-079

Shinn, J. N. (General Electric Company)

REVERSIBLE FLUID BINARY COUNTER

U. S. Patent No. 3,199,782 dated August 10, 1965, filed August 28, 1963

    The principal object of this invention is to provide an improved digital-type
fluid amplifier circuit that operates as a reversible binary counter.

S-080

Shook, T. A., Chen, T. F.; Reader, T.

FLUID AMPLIFICATION 12 BINARY COUNTER DESIGN

DDC Report AD617699 (UNIVAC Division Sperry Rand Corporation for contract
DA49 186AMC34X, November, 1964)

The report is a detailed account of the work carried out by UNIVAC pursuant
to contract number DA-49-186AMC-34(X). It is of special interest in this contract
to develop analytical tools which indicate circuit values in the construction of
an all-fluid system, and which then predict its operating characteristics.
In short, a circuit theory is to be formulated. An N-Stage Binary Counter is
selected for analysis, the foundations of which are the analogous equations of fluid
flow and electrical current, and empirically formulated element characteristics.

S-081

Shvetsova, V. I.

DIFFERENTIAL AMPLIFIER FOR MEASURING SMALL ATTENUATIONS

USSR Report Pribory 1· Tekhnika Eksperimento, Vol. 9, March-April, 1964, Pages 90-92
In Russian, (1AA Report A 64-20036)

Description of a differential amplifier for measuring the effectiveness of
coaxial attenuators in the range 500-1000 Mc. Attenuations from 0.1 to 1.0 db
are measured with an accuracy of ± 0.02 db.

S-082

Sickles, W. E.

VISCOUS MIXING OF TWO-DIMENSIONAL JETS WITH PARTICULAR REFERENCE TO JETS IN GROUND
PROXIMITY

DDC Report AD600 499 (Frost Engineering Division Report on Contracts DA44 177AMC 71T
1D021701A04814

Existing jet mixing theory is reviewed and compared with available experimental
results. Simple mixing equations are developed and used to determine the total
pressure variation in a two-dimensional jet and the effect of a static pressure
change on momentum flux. The effects of free-air entrainment are studied and
potential flow solutions given for three particular cases. A method of calculating
the lift loss due to vortices arising from viscous mixing is derived and gives good
agreement with experiment.

S-083

Sieracki, L. M.; Campagnuolo, C. J.

A DIGITAL-PROPORTIONAL FLUID AMPLIFIER FOR A MISSILE CONTROL SYSTEM

See Author Campagnuolo, Carl J.

S-084

Sieracki, L. M.; Campagnuolo, C. J.; Foxwell, J. E.; Holmes, A. B.

APPLICATION OF FLUERICS TO MISSILE ALTITUDE CONTROL

See Author Campagnuolo, C. J.

S-085

Simbulan, Vincent (Lockheed Missiles & Space Company)

INCREASING FLUID INJECTION THRUST VECTOR CONTROL EFFECTIVENESS

Paper presented at the SAE-A6 meeting, September 14-18, 1964

    Secondary fluid injection in this particular usage is concerned with the inject-
ion of a liquid into the main gas stream of the vehicles rocket motor, the injection
point being within the divergent cone of the motor nozzle. This method is being
utilized on the Polaris vehicle and is in the final stage of development for the
improved version of the Minuteman, thus demonstrating the operational feasibility of
the system.

S-086

Simson, A. K. (General Dynamics Corporation)

GAIN CHARACTERISTICS OF SUBSONIC PRESSURE-CONTROLLED, PROPORTIONAL FLUID JET
AMPLIFIERS

ASME Paper 64-WA/AUT-2 for meeting November 28-December 3, 1964

    Gain characteristics of amplifiers are developed in relation to control-port and
receiver-design parameters; analysis uses. Assumed submerged-jet representation;
receiver characteristics are presented in series of design curves; complete amplifier
characteristics are obtained by combining control-port and receiver characteristics;
example calculation is shown.

S-087

Simson, A. K.; Brown, Forbes T.

RESEARCH IN PRESSURE-CONTROLLED FLUID JET AMPLIFIERS

See Author Brown, F. T.

S-088

Slezenko, Z. F.

THE LOCAL METHOD FOR DIRECT MEASUREMENT OF THE BOUNDARY-LAYER VELOCITY PROFILE
OF A NONUNIFORMLY HEATED FLAT PLATE

DDC Report AD600 809 (Unedited Rough Draft Trans. of Inzhenerno-Ezicheskii, Zhurnal
(USSR) 1962, April 1964

In this article are examined the theoretical principles of a measuring method,
an equation for sensitivity of the measuring device, a method of calculating
velocity from a nomogramm, the fundamentals of a local method for direct measuring
of a velocity profile, and the principles of operating the experimental device.

S-089

Smetana, F. O.; Williams III, J. C.

THEORETICAL STUDY OF A CONVERGENT NOZZLE AND FREE JET FLOW

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. I, October 26-28, 1965

See Author Williams III J. C.

S-090

Smith, Paul D.

AN INVESTIGATION OF CYLINDRICAL STATIC PRESSURE PROBES

DDC Report AD604829 (Air Force Institute of Technology Wright Patterson AFB)
(Master's Thesis) June, 1964

The cylindrical pressure probe is a convenient device for the measurement of
the static pressure of a fluid stream. The indicated pressure, however, is a
function of the angular position of the probe relative to the direction of flow.
It is therefore necessary to know the probe angular position at which true static
pressure is indicated for the probe-flow situation at hand. In this study values
of the probe angular position are determined for ten different probe geometries
in a Reynolds number range from 2,500 to 15,000. The method used was to place the
probes in a stream of air that is being ejected into the atmosphere. The static
pressure of such a stream is equal to the local barometric pressure. Plots of the
results show the dependence of the probe angular position on probe diameter,
orifice diameter, and Reynolds number.

S-091

Smith, T. J. B; Powell Alan

AN AEROSONICS BIBLIOGRAPHY-SUPPLEMENT NO. 1

DDC Report AD 600455 (University of California Contract NONR 23362   N RO62229)
April, 1964

    See Author Powell, Alan

S-092

Society of Automotive Engineers

PROCEEDINGS OF THE SOCIETY OF AUTOMOTIVE ENGINEERS, AEROSPACE FLUID POWER SYSTEMS
AND EQUIPMENT CONFERENCE, May 18-20, 1965, 1AA-A65-28019

    Conference sponsored by the Society of Automotive Engineers, New York.
Society of Automotive Engineers., 1965, 471 pages.

S-093

Soehngen, E. E.; Holman, J. P.

EXPERIMENTAL STUDIES ON THE INTERACTION OF STRONG SOUND FIELDS WITH FREE CONVECTION
BOUNDARY LAYERS

Report 277 presented at the Boundary Layer Research Meeting of the AGARD Fluid
Dynamics Panel held from 25-29 April 1960, in London, England.

See Author Holman, J. P.

S-094

Sorensen, P. H.; Lechner, T. J.

SOME PROPERTIES & APPLICATIONS OF DIRECT & TRANSVERSE IMPACT MODULATORS

See Author Lechner, T. J.

S-095

Sowers, E. U. III (Sperry-Rand)

FLUID AMPLIFIER WITH AUTOMATIC RESET OF THE POWER STREAM

U. S. Patent No. 3,122,039, February 25, 1964

This invention relates to apparatus for converting a fluid energy pulse into
a mechanical energy pulse, which finds particular utility in magnetic tape-to-card
punch devices and the like. One of the novel features of this invention is the
provision of a pure fluid amplifier of the boundary layer type whose power jet
stream acts as the prime motive force on the mechanical body. There is
further provided automatic reset of the power stream to a stable quiescent
condition after the body is driven to perform work whether it be of punching,
printing, impact or the like.

S-096

Sowers, E. U. III (Sperry-Rand)

FLUID POWER AMPLIFIER NOT-GATE

U. S. Patent No. 3,174,497 dated March 23, 1965, filed September 4, 1962

This invention relates to pure fluid amplifiers for performing logical functions. More particularly, this invention provides fluid amplifiers for performing the logical NOT or inhibit function the amplifier having means for producing a power stream jet, at least one control stream jet and at least one inhibit stream jet, the amplifier being characterized by the fact that the inhibit stream jet flows in a path which is substantially normal to the plane in which the control and power stream jets flow.

S-097

Sowers, E. U. III; Bauer, P. (Sperry-Rand)

FLUID SORTER

U. S. Patent No. 3,169,639 dated February 16, 1965, filed August 19, 1965

See Author Bauer, P.

S-098

Sowers, E. U. III (Sperry-Rand)

MULTI-FREQUENCY FLUID OSCILLATOR

U. S. Patent No. 3,117,593 dated January 14, 1964, filed April 23, 1962

This invention relates to a pure fluid oscillator and more particularly to one having a plurity of stable non-simultaneous output frequencies.

S-099

Sparrow, H. T.

FLUID AMPLIFIER MIXING CONTROL SYSTEM

U. S. Patent 3,091,393, May 28, 1963

The present invention is directed to a fluid control system, more specifically it is directed to a hot water mixing system for the utilization of a single hot water tank for the supply of an intermixed or temperature controlled water flow at various locations in a home or building.

S-100

Sparrow, H. T.   (Honeywell, Inc.)

GAS CONTROL SYSTEM

U. S. Patent No. 3,171,468 dated March 2, 1965, filed May 9, 1961

This invention is directed to a gas burner control system for the efficient utilization of a plurity of pilot gas flow rates more specifically the present invention is directed to the use of a fluid amplifier for switching gas between two burners for efficient burning of the gas under widely flow rate conditions.

S-101

Sparrow, H. T. (Honeywell, Inc.)

PULSED FLUID AMPLIFIER

U. S. Patent No. 3,176,703, dated April 6, 1965, filed March 1, 1962

This invention is directed to a type of fluid amplifier that utilizes control jets for shifting a main fluid stream between two or more outlets. More specifically this invention is directed to the utilization of variable volume chambers to seal the control jet passages thereby providing a means of obtaining fluid pulses from the central or main fluid stream without the addition of or control of, separate fluid sources to the fluid amplifier.

S-102

Spivak, A. L.

ARC DISCHARGE CONTROLLED FLUID AMPLIFIER

U. S. Patent No. 3,122,062, February 25, 1964

This invention relates to a fluid valve or amplifier of the type which controls fluid flow by use of small control fluid flows acting to react with the main fluid stream, and in particular to a fluid amplifier utilizing an arc discharge means to control the control fluid flow. In this type of device a main flow passageway is connected to a juncture from which branch passageways lead off. At the point where the main flow enters the juncture, side ports for passage of control fluid flow normal to the main flow are provided which by selectively allowing each control fluid to flow will control the main flow by deflecting it into the desired branch passage. These devices are therefore referred to as fluid amplifiers because of the fact that a small control fluid flow may be utilized to control the flow of a large fluid stream.

S-103

Springett, B. E.; Schwarz, K. W.; Donnelly, R. J.

MODES OF INSTABILITY IN SPIRAL FLOW BETWEEN ROTATING CYLINDERS

Journal of Fluid Mechanics, 1964, Vol. 20, Part 2, Pages 281-289

See Author Schwarz, K. W.

S-104

Spyropoulos, C. E. (Harry Diamond Lab.)

A SONIC OSCILLATOR

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. III, May 26-28, 1964

A bistable pneumatic element was caused to oscillate by providing an external feedback interconnection between its two control nozzles. The effects of oscillator control interconnection length, diameter, and power-jet pressure on oscillator pulse rate were experimentally determined. These experimentally determined oscillator characteristics are compared with the theory. The oscillator control interconnection pressure wave phenomenon is also investigated.

S-105

Spyropaulos, Chris; Campagnuolo, Carl J.

A TWO-STAGE DIGITAL AMPLIFIER APPLIED TO THE ARMY ARTIFICIAL HEART PUMP

   See Author Campagnuolo, Carl J.

S-106

Srinivas, V.; Besant, R. W.

FLUID DYNAMIC EFFECTS OF LIQUIDS IN ELASTIC TUBES

   See Author Besant, R. W.

S-107

Stanford Research Institute (Long Range Planning Service, November, 1963)

BIBLIOGRAPHY - FLUID AMPLIFIERS FOR COMPUTATION AND CONTROL

S-108

Stanford Research Institute, Menlo Park, California

FLUID AMPLIFIERS

A research report (No. 209) by the Long Range Planning Service, April, 1964

   Fluid amplifiers compare in many respects with the transistor, except that they operate through modulation of fluid flow instead of electricity.

   First major uses will come in controls in military and space systems where fluid amplifiers' unique resistance to hostile environments (radiation and high temperatures) will be worth the expected high developmental cost.

   Equipment potentially utilizing fluid amplifiers in control systems includes aircraft and automotive gas turbines and other power equipment, machine tools, hydraulic transmission systems, and possibly some office machines such as desk calculators and automatic typewriters.

   Fluid amplifiers will not be able to compete with electronics in such equipment as general purpose computers, because they have not the requisite speed.

   Further research will bolster fluid amplifier prospects, and will focus on: the dynamics of the devices, which are still difficult to understand; further study of the type with moving parts; and applied R&D.

S-109

Stanford Research Institute, Menlo Park, California

INSTRUMENTATION FOR AND EXPERIMENTS ON TACTUAL PERCEPTION

Quarterly Report 1 - covering the Period 15 September to 15 December, 1963.

This report covers the first quarter of a program on the perception of tactile stimuli for transfer of pattern information and vehicle control information. The report describes computer programs and equipment under development, as well as some experiments that have already been performed.

A set of computer programs have been written that store stimulus patterns and scan these patterns according to several time sequences. Programs are being written to record and analyze subjects; responses.

Experiments were performed to compare various methods of conveying magnitude (e.g., of a vector) information. Results from these experiments indicate the most promising techniques for further investigation.

S-110

Steiner, L. A

FLUID LOGIC AND CONTROL DEVICES

The Engineer, August 20, 1965

Several American & Russian patent specifications concerning "fluid" control systems which appeared nearly simultaneously in 1959-60 indicated an effort to develop analogue and digital components and systems of small dimensions, operated by fluids instead of electronics. This met the need of computations and logic operations in missiles and space craft, where high temperatures, severe radiation, vibration or other adverse conditions preclude the use of transistors and similar elements. These and other advantages induced attempts of industrial applications and recent progress in this field is here assessed.

S-111

Steiner, L. A. (Ph. D. Automation Consultant)

UNDERSTANDING FLUID AMPLIFIERS

Instrument and Control Engineering, July, 1965

Interest in fluid logic and fluid amplifier techniques is quickening. In 1962 the first fluid amplification symposium was organized by the Harry Diamond Laboratories. Thirty-three papers were presented. The second symposium was held in 1964 in Washington, 55 papers were presented, seventeen of these were from the laboratories own staff, ten from universities and twenty-six from Industrial organizations. This article is the first of a series of two articles which sets out the modes of operation of jet-type fluid-operated elements for control purposes. In the second article fluid logic will be compared with its electrical and mechanical counterparts and applications and future trends discussed.

S-112

Stern, Hans; Gray, W. E. (General Electric Company)

FLUID AMPLIFIERS: CAPABILITIES & APPLICATIONS

See Author Gray, W. E.

S-113

Stoeffler, R. C.; Olsen, R. E.

A STUDY OF FACTORS AFFECTING THE TIME RESPONSE OF BISTABLE FLUID AMPLIFIERS

See Author Olsen, R. E.

S-114

Straub, H. H. (MSE); Meyer, J. (M. D.) (Harry Diamond Labs)

AN EVALUATION OF A FLUID AMPLIFIER, FACE MASK RESPIRATOR

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. III, October, 1965

A small fluid amplifier respirator has been evaluated. Results indicate that the respirator performs well on both animals and humans. High expiratory resistance, a characteristic of the device is overcome with the addition of a specially designed breathing valve that can be eliminated, if necessary, for certain types of patients with respiration difficulties requiring higher-than-normal mean lung pressures. The elimination of moving parts in the respirator itself makes this device extremely reliable, easy to operate, and inexpensive to manufacture.

S-115

Straub, Henrick H. (Harry Diamond Labs.)

FLUID AMPLIFIER HELPS PATIENTS BREATHE

Control Engineering, April, 1965, Page 120, April, 1965

A bi-stable fluid amplifier with a feedback loop from the left receiver to the left control nozzle - controls the flow, pressure, and cycling rate of gases that are breathed in an automatic respirator. The respirator was developed by Harry Diamond Labs and the Walter Reed Army Institute. The fluid amplifier block, which is about the size of a cigarette pack, consists of a bottom plate, into which the amplifier is machined - and a cover plate.

S-116

Straub, Henry; Mon, George; Joyce, James; Woodward, Kenneth

FOUR FLUID AMPLIFIER CONTROLLED MEDICAL DEVICES

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. IV, May 26-28, 1964

See Author Woodward, Kenneth

S-117

Streeter, V. L.

HANDBOOK OF FLUID DYNAMICS

Section 20 Fluid Transients in Engineering Systems book published by McGraw-Hill
Book Co., Inc., New York, 1961

S-118

Stuttgart, T. H.; Wiesner, H. J.; Rüdle, M. A   (Germany)

FLUID DEVICES FOR MACHINE CONTROLS

Paper given at the First Conference on Fluid Logic and Amplification sponsored
by the British Hydromechanics Research Association and College of Aeron. Cranfield,
England, September 9-10, 1965

S-119

Swartz, E. L. (Harry Diamond Labs)

A FLUERIC INDUCTION AND GATE

Proceedings of the HDL 3rd Fluid Amplification Symposium, October, 1965, Vol. IV

The characteristics of the fluid induction AND logic unit are discussed. The
principle of operation of this empirically designed device and the impedance
matching technique employed to adapt it to fluid circuits are discussed.

T-017

Taft, C. K. (Case Institute)

A FLUID ENCODING SYSTEM

The development of an encoding system using pure fluid devices is described. The system consists of three portions: a device to quantize an angular rotation into incremental digital fluid signals, a logic section to shape the fluid pulses, a section to sense direction of rotation and a bi-directional counter. The input to the counter is the angular position in quanta from the point at which the counter is reset. The counter sums algebracially the number of feedback pulses received. A slotted disk rotating between two sets of opposed nozzles, is employed as the quantizer. The slots equally spaced circumferentially allow fluid flow from supply nozzle to receiver nozzle while the spaces between slots inhibit such flow.

T-018

Taft, C. K. Dr.; Turnquist, R. O. (Case Institute of Technology)

A FLUID STATE DIGITAL TO ANALOG CONVERTER

Design requirements were established for a fluid state D/A converter to be used in a fluid state digital pulse data control system. TWO D/A converter designs satisfying these requirements were built and tested. One design used simple nonlinear thin plate orifices and produced a reasonably linear static output pressure characteristic. The other design used linear orifices and a bias stage and produced a linear static output pressure characteristic. Both designs were tested statically and dynamically. Static test results were in good agreement with those predicted by theory. Dynamic testing was limited to fairly low counter pulse rates, but it was possible to predict the dynamic capability of the linear orifice design from its transfer function.

T-019

Taft, C. K.; (Case Institute) Koerper, P. E. (Koerper Engineering)

FLUID STATE POWER AMPLIFIER DESIGN

Paper presented at the 21st National Conference on Fluid Power, Chicago, Illinois, October 22, 1965

The recent development of fluid amplifiers opens up many new applications for fluid control. These developments are based on the idea that a fluid, a liquid or a gas, can be controlled by a fluid in a valve with no moving parts. This process can be accomplished in many ways and essentially the approaches developed in the last 5 or 6 years depend upon the control of some fluid mechanical phenomena. In each of these approaches, there is some degree of amplification in that the power level of the fluid signal is less than the power level of the fluid being controlled.

T-020

Taft, C. K.; Greber, I.; Koerper, P. E.

FLUID VORTEX AMPLIFIER OPTIMIZATION

See Author Greber, I.

T-021

Taft, C. K. (Case Institute)

IMPACT OF FLUID AMPLIFIERS ON DESIGN OF METAL WORKING MACHINES

ASME Publication 65-MD-43, June, 1965

The work being conducted at Case Institute of Technology in the Design Center by the control system synthesis group is concerned with finding the role of the pure fluid amplifier in control. An attempt is being made to develop the design techniques which not only will define the capabilities of pure fluid amplifiers but will enable design engineers to develop control systems using these elements. In addition, this work is concerned with some of the basic properties of these elements and how they can be designed to produce elements of optimum capability. From what has been learned, it is believed that the pure fluid amplifier has a place in many automatic control applications. Machine-tool control is one of these areas where the fluid amplifier has much to offer.

T-022

Talley, P. E. Jr.; Bates, Richard, L.

PNEUMATIC DIGITAL ACCELEROMETER

SEE Author Bates, R. L.

T-023

Tamulis, J. C

SIGNAL NOISE IN PURE FLUID AMPLIFIERS

NASA-CR-62882 (Pennsylvania State University Report NGR-39-009-023, April, 1965)

A literature search and the formulation of a program relative to studies of signal noise in pure fluid amplifiers has been completed, and two large-scale fluid amplifiers and a deep water table for experimental use have been constructed. A prototype pneumatic motor was constructed that uses flexible bags instead of bellows for the conversion of pulse pressures. A computer-aided investigation of a hydraulic stepper, utilizing a cam groove to produce a net increment of linear or rotary output movement from the reciprocating motion of the cam, proved its feasibility for use as an actuator in remote control and/or automatic control systems. Analytical and phase plane studies of hysteresis-caused instabilities in closed loop control systems showed that introduction of a switching logic network restores the stability. Other studies were: Dynamics of fluid transmission lines; Experimental High Performance Electric Servomotor with Minimum Weight and Size; Fluid Amplifiers and Stability; Time-Delay Characteristics in Systems Employing Vortex Devices; and Steam-to-Air Converter.

T-024

Tanney, J. W.

DEVELOPMENT IN PURE FLUID SYSTEMS COMPONENTS AND CONTROL DEVICES (Part I)

Reprint of Article from DME/NAE Quarterly Bulletin, No. (A64-20777), April, 1964

The components used in pure fluid systems are described with emphasis on their general method of operation and generic characteristics. Active components (amplifiers) are classified according to the phenomena that are utilized in their operation and typical characteristics are described. Passive components are briefly noted in relation to their principal characteristics. Logic devices are described in relation to circuit function.

T-025

Tanney, J. W.

DEVELOPMENT IN PURE FLUID SYSTEMS, COMPONENTS AND CONTROL DEVICES (Part II)

Reprint of Article from DME/NAE Quarterly Bulletin No. 1964 (2), A6426011, June, 1964

Some of the complex pure fluid components and some typical systems are described. Schematic symbols and typical circuits are illustrated. Manufacturing techniques, problem areas, the present state of the art and potential applications are discussed. Sources of additional information are given in a brief annotated bibliography.

T-026

Taplin, L. B.; Hall, J. F.

PROGRESS OF THE U. S. AIR FORCE RESEARCH AND TECHNOLOGY DIVISION FDL PROGRAM SYNTHESES OF A PURE FLUID FLIGHT CONTROL SYSTEM

Paper given at the AIAA/ION Guidance and Control Conference, August, 16-18 1965, Minneapolis, Minnesota

T-027

Testerman, M. K.; McLeod, P. C. (Phillips Petroleum Company)

METHOD AND APPARATUS FOR DETERMINING FLUID FLOW RATE

U. S. Patent No. 3,144,767 dated August 18, 1964, filed July 3, 1961

This invention relates to utilizing an ultrasonic frequency wave generator as a fluid volumetric flowmeter. In another aspect it relates to using said generator as a mass flowmeter for a fluid of constant or known composition.

T-028

Timma, E.

ANALYTIC INVESTIGATION OF TURBULENT FLAT JET, DEVELOPING IN A CO-STREAM

DDC Report AD609150 (Foreign Tech. Div. Air Force Systems Command WPAFB)
Unedited rough draft trans. of Akademiya, Nauk Estonskoi SSR. Tallinn. Izvestiya,
Seriya Fiziko-Matematicheskikh, I Tekhnicheskikh Nauk, Vol. 12, No. 1 Pages 57-74

With the help of the proposed method, analytical formulas were obtained for
determination of the characteristics of all sectors of a turbulent plane-parallel
jet, which developed in a co-stream.

T-029

Toepfer, H.; Schrepel, D.; Schwarz, A.

UNIVERSAL ASSEMBLY OF PREFABRICATED MACHINE PARTS FOR PNEUMATIC GUIDANCE CONTROL

DDC Report AD-608461 (Foreign Tech. Div. Air Force Systems Command WPAFB) Unedited
rough draft Trans. of Messin - Steuern - Regeln, East Germany, 1963)

Developments of emission elements of guidance control in the field of
pneumatics are discussed. The advantage of emission elements consists of the fact
that they do not have any moving parts and thus posses great longevity and
extensive switch velocity. In addition, temperature independence can be achieved by
selecting suitable materials. An assembly of prefabricated parts which are
developed by taking into consideration these points and which close the gap between
the disadvantages analogous elements and the emitter which currently are not yet
suitable for industrial application is presented.

T-030

Togino, K.; Inoue, K.

UNIVERSAL FLUID LOGIC ELEMENT

Control Engineering, May, 1965

Cascading two small four-way pneumatic piston units in one housing yields a
universal logic element. From both the logical design and practical equipment
view points, these elements can be easily combined into all kinds of logic circuits
including such things as flip flops, registers, and counters. This article gives a
brief look at the background logic, a description of the element, and a rundown on
the circuits to control a transfer machine.

T-031

Töpfer, H.

PNEUMATIC LOGIC ELEMENTS AND APPROPRIATE PERIPHERAL EQUIPMENT

Paper No 1.3 presented at the IFAC/IFIP Symposium on Microminiaturization in Automatic Control Equipment and in Digital Computers, held in Munich, Germany, October 21-23, 1965

Logic elements described in this paper (membrane type elements) offer the advantages of power amplification and very long life (4×10^9 operations); furthermore the membrane type elements may be used in conjunction with fluid elements using no moving parts.

T-032

Trask, P.; Frey, K. P. H.; Vasuki, N. C.

NEW COMPREHENSIVE STUDIES ON SUDDEN ENLARGEMENTS

See Author Frey, K. P. H.

T-033

Tsui, Ka-Cheung; Belsterling, C. A.

ANALYZING PROPORTIONAL FLUID AMPLIFIER CIRCUITS

See Author Belsterling, C. A.

T-034

Tsui, K. C.; Belsterling, C. A.

APPLICATION TECHNIQUES FOR PROPORTIONAL PURE FLUID AMPLIFIERS

See Author Belsterling, C. A.

T-035

Tu, Yih-O,; Watson, T. J., Cohen, H.

A THEORETICAL MODEL FOR SEPARATION IN THE FLUID JET AMPLIFIER

1AA Report A64-10761, Also, IBM Journal of Research & Development Vo. 7, October, 1963, Pages 288-296

See Author Watson, T. J.

T-036

Turnquist, R. O.; Taft C. K. (Dr.) (Case Institute)

A FLUID STATE DIGITAL TO ANALOG CONVERTER

Proceedings of the HDL 3rd Fluid Amplification Symposium, October, 1965, Volume III

See Author Taft, C. K. (Dr.)

U-002

Uginciu, S. P.; Schwiderski, E. W.,; Lugt, H. J.

AXISYMMETRIC VISCOUS FLUID MOTIONS AROUND CONICAL SURFACES

DDC Report AD600962 (Naval Weapons Lab.)

    See Author, Schwiderski, E. W.

U-003

Underwood, F. A.; Hahn, G. J.; Shinn, J. N. (G. E. Company)

PROCEDURE FOR OBTAINING FLUID AMPLIFIER RELIABILITY DATA

NASA Report prepared by the General Electric Co. for Contract NAS-8-5408, November, 1965

    See Author Shinn, J. N.

U-004

Unfried, H. H.

AN APPROACH TO BROAD BAN FLUID AMPLIFICATION AT ACOUSTIC FREQUENCIES

Proceedings of the HDL Fluid Amplification Symposium, Vol I, October 26-28, 1965

    The philosophy of operating conjugate fluid jets in the highly nonlinear
flow region for acoustic amplification is outlined. Operation is necessarily
restricted to laminar flows which are inherently sound sensitive and which are
allowed to develop into vortex flow patterns; hence the amplifier is best suited
for low level input signals. A sound sensitive jet is by itself somewhat selective
frequency-wise with an operational bandwidth on the order of an octave, whereas
the nature of the conjugate jet system allows bandwidths of many octaves; and
perhaps its most novel feature is amplification acoustic speech range of from 200
cps to 8,000 cps. The power gain per stage is generally smaller than the gains
reported for other types of fluid amplifiers which typically operate at lower
frequencies.

U-005

Unfried, H. H.

EXPERIMENT & THEORY OF ACOUSTICALLY CONTROLLED FLUID SWITCHES

Proceedings of the HDL Fluid Amplification Symposium, Vol. II, October, 1965

Frequency selective acoustically controlled fluid dynamic switches are discussed in terms of Reynolds number, Strouhal number, and geometric parameters. The successful operation of such a device depends on the simultaneous conditions that:

1. The stream, which is basically controlled by the boundary, is in the monostable region of operation.
2. That stream operation takes place in the region of flow where it is most sensitive to small disturbances. Such a flow region is specified in terms of Reynolds and Strouhal numbers.
3. An acoustic resonator is coupled to the orifice to increase the frequency selectivity and also act as a velocity amplifier which controls the flow at the orifice of the jet. It is important that the resonator be tuned to the frequency for which the flow is most sensitive.

U-006

USSR

PURE FLUID CONTROL DEVICES AND THE DESIGN OF PRINTED PNEUMATIC CIRCUITS

Publ. OTS: 63-31761, U. S. Department of Commerce, Office of Technical Services, Joint Publications Research Service, Washington, D. C.

During the course of the last six years research has been conducted in the laboratory of pneumohydraulic automatics of the Institute of Automatics and Telemechanics which has led to the establishment of a completely new principle of building pneumohydromatic devices. The devices of this new type differ fundamentally from these which were previously known. One of the distinctive characteristics of these devices is the fact that they are built with pure jet elements and other hydroaerodynamic action elements which do not contain mechanical moving parts while their operation is based on the interaction of the currents of the operating medium.

V-009

Van Tilburg, R. W., Cochran, W. L.

APPLICATION OF OPTICAL FABRICATION TECHNIQUES TO THE FABRICATION AND DEVELOPMENT OF FLUID AMPLIFIERS

Results from a program of design fabrication, and evaluation of pressure proportional fluid amplifiers, gain blocks, and circuits are presented. Included is a brief discussion of the development of a multistage, high amplification gain block, and from this device, the development of a rudimentary pneumatic analog scale changer incorporating feedback, plus the matching resistances. Data are also presented relative to staging studies which resulted in a five-stage, high gain amplifier with output stability and noise level adequate for preliminary experiments in the effect of feedback. The general conclusions to be drawn from the program are that the design and fabrication of functional, analog pure fluid computational circuits is feasible, that multistage gain blocks incorporating the basic HDL pressure gain design, or some relatively minor modification thereof, are capable of pressure gains well in excess of 10,000, and that fotoceram glass ceramic fluid amplifiers and the process for producing them have been developed sufficiently to permit the fabrication and evaluation of complex circuitry.

V-010

Van Tilburg, R. W. (Corning Glass Works)

AREA EXPERIENCE IN MODERATE VOLUME FABRICATION OF PURE FLUID DEVICES

A discussion of the background of Fluid Amplifier development leads into the decisions on production organization. Specifications in their most phenomenal sense are covered and the logic behind the specifications is explained briefly.

Production experience is summarized with facts on selections of specific devices produced to specific specifications. Conclusions indicate that Fluid Amplifiers have selection criteria similar to other control components. Other conclusions are drawn.

V-011

Van Tilburg, R. W.; Cochran, W. L. (Corning Glass)

DEVELOPMENT OF A PROPORTIONAL FLUID AMPLIFIER FOR MULTI-STAGE OPERATION

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. II, May 26-28, 1964

A presentation is made of the data and general information obtained during the development of a basic proportional device for use in fabrication of a multistage, high gain proportional amplifier.

Starting with a sound basic design of a pressure gain device submitted by Harry Diamond Laboratories personnel in conjunction with a fabrication program, a comprehensive study was undertaken directed toward maximizing the pressure gain while maintaining operating conditions which would permit direct in-line coupling of several identical devices.

V-012

Van Tilburg, R. W.; Brown, W. R.

FLUID AMPLIFIER

See Author Brown, W. R.

V-013

Van Tilburg, R. W.; Cochran, W. L.

THE STAGING OF PRESSURE PROPORTIONAL AMPLIFIERS TO PROVIDE STABLE MEDIUM GAIN, DUAL CONTROL; SINGLE OUTPUT PURE FLUID SYSTEMS

See Author Cochran, W. L.

V-014

Vasuki, N. C.; Frey, K. P. H.

FLOW STABILITY FOR TWO-DIMENSIONAL CUSP DEVICES

See author Frey, K. P. H.

V-015

Vasuki, N. C.; Trask, P.; Frey, K. P. H.

NEW COMPREHENSIVE STUDIES ON SUDDEN ENLARGEMENTS

See Author Frey, K. P. H.

V-016

Victory, E. L.

ANALYSIS OF THRUST AND FLOW AUGMENTATION OF A COANDA NOZZLE

DDC Report AD-617621 (Huyck Research Center Stanford, Conn. - Final Report)

In order to evaluate the performance of a coanda nozzle and to determine
its thrust and pumping capabilities, a series of tests were conducted on a
coanda nozzle. The results showed that the nozzle was capable of creating
thrust augmentation of about 1.25. Furthermore, it was also shown that the coanda
nozzle, through the creation of a low pressure zone along the coanda surface,
was capable of augmenting the momentum of the primary by a factor of approximately
1.7.

V-017

Vince, J. R.; Brown, C. C. (British Aircraft Corporation, U. K.)

THE APPLICATION OF FLUID JET DEVICES TO A MEDICAL RESPIRATOR

Paper given at the First Conference on Fluid Logic and Amplification September 9-10,
1965 sponsored by the British Hydromechanics Research Association and the College
of Aeron. Cranfield, England.

V-018

Vockroth, R. W. Jr. (Corning Glass)

FLUID AMPLIFIERS

U. S. Patent No. 3,202,179 dated August 24, 1965, filed February 5, 1962

This invention relates to fluid amplifiers and more particularly to devices
by which a relatively high pressure and/or relatively high volume stream of fluid
may be controlled or directed by a relatively low pressure fluid stream.

V-019

Vulis, L. A.

TURBULENT HEAT AND MASS TRANSFER IN JET MOTION OF A GAS

Topics include: 'Half-free" thermal (Diffusion) streams, propagating in a hard wall; investigation of heat exchange in complex (concurrent and counter, and also transverse and others) jets in tracking a body; twisted flows, especially under the conditions of strong twisting. An explanation is given of the possibility of a generalization in the case of compressible twisted streams.

W-023

Wadey, W. G. (Sperry- Rand Corp.)

FLUID LOGIC CONTROL

U. S. Patent No. 3,191,860 dated June 29, 1965, filed January 30, 1963

This invention relates to a method and means for controlling digital, fluid-actuated systems more particularly to a method and means for controlling the generation of timing pulses at a frequency dependent upon the rate at which the pulses can be propagated through the system.

W-024

Wadey, W. G. (Sperry-Rand)

FLUID PULSING MEANS FOR PRINT HAMMERS

U. S. Patent No. 3,159,099 dated December 1, 1964, filed August 16, 1964

This invention relates to apparatus for converting energy of relatively long duration into impulse energy of relatively short duration and more particularly to a fluid variable linkage mechanism for actuating the print hammer in a print in a mechanism.

W-025

Wadey, W. G. (Sperry-Rand)

INFRARED RECORD READER WITH FLUID SIGNAL OUTPUT

U. S. Patent No. 3,179,810 dated April 20, 1965, filed October 4, 1961

This invention relates to means for sensing the presence of a mark on a carrier member, and more particularly, to apparatus for producing a change in the pressure of an enclosed fluid system in response to the detection of a mark. A rapidly developing area in the field of digital data processing systems is the use of pure fluid amplifiers for the transmission and manipulation of information pulses in a fluid medium.

W-026

Walberer, J. C.; Rivard J. G. (Bendix Corp.)

A FLUID STATE VORTEX HYDRAULIC SERVOVALVE

Paper presented at the 21st National Conference on Fluid Power, Chicago, Illinois
October 22, 1965

    See Author Rivard, J. G.

W-027

Walker, G. K.; Schumann, B. A.

A DISCUSSION OF NESS'S ANALYSIS FOR A TURBULENT BOUNDARY LAYER WITH MASS ADDITION

DDC Report AD 600 627 (General Electric Co. MSD Report R61SD49) Contract AF04 647 715,
1961

    The governing equations of Ness's analysis of the turbulent boundary layer
with air injection have been solved by means of digital computer. The results
of the calculations are presented for various free-stream and local conditions.
The results of Ness's analysis for air injection are compared with experimental
data, and agreement is seen to be poor.

    A comparison of Ness's theory with incompressible velocity profile data provides
a possible explanation for the discrepancy. A comparison of Ness's analysis for
helium injection and experimental data shows good agreement for zero to moderate
injection rates, and poor agreement for high injection rates. Therefore,
it is concluded that for the general case of a turbulent boundary layer with mass
addition, extreme caution should be employed when applying Ness's analysis.

W-028

Walker, G. K., Schumann, B. A.

THE GROWTH OF TURBULENT BOUNDARY LAYERS

DDC Report AD-601503 (G. E. Co. Missile & Space Division for Contract AF04(645)24
July, 1964)

    Turbulent boundary-layer theory and experimental data are combined to yield
engineering relations for the total, momentum, and displacement boundary-layer
thickness, for local mach numbers between zero and five, the Eckert Reference-enthalpy
method is shown to correlate the experimental momentum thickness data obtained from
flows over a non-porous flat plate with zero dissociation.

W-029

Walker, W. F.; Zumwalt, G. W. (Oklahoma State)

THE ANALYSIS OF SUBMERGED JET FLOW FIELDS BY A NUMERICAL FIELD COMPUTATION METHOD

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. IV, October, 1965

    See Author Zumwalt, G. W.

W-030

Walston, William H. (Jr.)

TRANSIENT RESPONSE OF A FLUID LINE WITH AND WITHOUT BLEEDS

Proceedings of the HDL Fluid Amplification Symposium, Vol. II, October 1965

    The theory of characteristics is applied to determine the transient response of rectangular ducts to a step input. The step input is generated by a unique film-snatching apparatus. The output pulse of the duct is shaped by a nozzle termination and by the addition of side branches to the duct. Only subsonic flow is considered. Experimental results that confirm the theoretical predictions are presented.

W-031

Warren, R. W. et al

FLUID LOGIC COMPONENTS

U. S. Patent No. 2,107,850, October 22, 1963

    This invention relates to pure fluid logic components capable of performing logic functions without moving parts.

    Electronic logic components capable of performing the basic arithmetic functions of addition, subtraction, multiplication and division are conventional in the computer art. Such networks typically include "AND-NOT" and "OR-NOR" components which, when properly combined, accomplish the desired logic function of the counter or computer.

W-032

Warren, R. W. (Harry Diamond Lab.), 1964

FLUID LOGIC ELEMENTS

DDC Report AD-613710 (Harry Diamond Lab.), 1964

There are several fluid amplification techniques that can be used in logic systems. This discussion is concerned with fluid elements using the technique of attaching a stream to a wall. In designing logic systems from such elements there are two methods of connecting the elements to accommodate the flow. These are sometimes called the closed system and the bleed system. In the closed system the successive elements are made larger and larger to accommodate all the flow of the previous stages. This type of system is employed for multistage flow and pressure amplifiers. All the fluid supplied at the inputs is available at the output for efficient use of power. Because the size of each unit must be adjusted to that of the preceding one, such a design is not practical for the more complex logic systems. When the bleed method is adopted to logic-systems, it is desirable form the standpoint of simplicity that the fluid elements have the following characteristics (1) same size (2) same pressure source and (3) equal pressure drop across nozzle, i.e. equal flow.

W-033

Warren, R. W.

FLUID OSCILLATOR

U. S. Patent No. 3,016,066 dated January 9, 1962, filed January 22, 1960

This invention relates to a fluid-operated system which utilizes the flow of a fluid so that the system performs functions which are analogous to some functions now being performed by electronic components and systems.

W-034

Warren, R. W. (Harry Diamond Labs.)

FLUID TIME GATE

U. S. Patent No. 3,180,575 dated April 27, 1965

This invention relates generally to pure fluid amplifying systems and more specifically to a pure fluid time gate capable of gating fluid input signals without the use of moving mechanical parts.

W-035

Warren, R. W.

FLUID VORTEX TRANSFER

U. S. Patent No. 3,207,168 dated September 21, 1965, filed January 16, 1963

This invention relates generally to a unit for providing a low energy loss transfer of linear flow between two planes of flow, and more specifically this invention relates to a device for use in a pure fluid system for providing an impedance match to the system.

W-036

Warren, R. W. (Harry Diamond Laboratories)

INTERCONNECTION OF FLUID AMPLIFICATION ELEMENTS

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. III, May 26-28, 1964

The interconnection of fluid logic elements necessitates that both flow and wave effects be considered. Practical considerations impose additional limitations on the system. Some approaches to the problem of operating within these limitations are discussed.

The operation of a wall-interaction fluid amplifier with open controls and with a minimum setback between the stream and the walls is discussed. It is shown that a decrease in flow in the control on the side of the stream opposite the separation bubble is very effective in switching the stream. Characteristics of the output waves are reported.

Techniques used to solve interconnection problems are discussed.

W-037

Warren, R. W. (Harry Diamond Labs)

NEGATIVE FEEDBACK OSCILLATOR

U. S. Patent No. 3,158,166 dated November 24, 1964, filed August 7, 1962

This invention relates generally to fluid oscillator systems having no moving solid parts in which amplification is a function of magnitude of deflection of a main fluid jet by a transverse fluid pressure distribution, and in which oscillation is a function of the transverse fluid pressure fed back from the main fluid jet.

W-038

Warren, R. W.; Bowles, R. E.

PERFECTIONNEMENT AUX SYSTEMES ACTIONNES PAR UN FLUIDE

French Patent No. 1,278,782 dated November 23, 1960

W-039

Warren, R. W.; Bowles, R. E.

THREE DIMENSIONAL JET VECTORING SYSTEM

U. S. Patent No. 3,204,405 dated September 7, 1965, filed February 20, 1964

This invention relates to a pure fluid control system for controlling the flight of missiles,rockets and reaction propelled vehicles.

W-040

Watson, T. J.; Tu, Yih-O, Cohen, H.

A THEORETICAL MODEL FOR SEPARATION IN THE FLUID JET AMPLIFIER

1AA Report A64-10761, Also IBM Journal of Research and Development Vol. 7, October, 1963, Pages 288-296

Theoretical study, based on the re-entrant jet model of the growth of the separation region in the fluid jet amplifier, a bistable device that offers possibilities as a logic element for computers and as a control element. The flow is taken to be inviscid but dissipation of momentum is obtained by means of the re-entrant jet. The effect of control port pressure and wall angle on the size of the separation region is calculated. Several other versions of the model are suggested.

W-041

Weinger, S. D. ; Gottron, R. N.

FLUID AMPLIFIERS: PARAMETERS AFFECTING THE NOISE IN NO-MOVING-PARTS FLUID DEVICES

See Author Gottron, R. M.

W-042

Weinger, S. D. (Harry Diamond Labs)

THE EFFECT OF SOUND ON A REATTACHING JET AT LOW REYNOLDS NUMBERS

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. IV, October, 1965

An explanation is given for the effect of sound on the reattachment point of a jet to an offset wall. The explanation depends on combining the movement of the reattachment point with jet Reynolds number and the effect of sound on the transition region of a jet from laminar to turbulent flow. The movement of the reattachment point with sound amplitude is found to be due to changing the location of the transition region. Typical experimental results are described.

W-043

Weinger, S. D.

THE EFFECT OF SOUND ON THE ATTACHMENT OF A JET TO AN OFFSET WALL

Harry Diamond Lab. - Internal Report R-RCA-6417, August 24, 1964

An explanation is given for the effect of sound in the reattachment point of a jet to an offset wall. The explanation depends on combining the movement of the reattachment point with jet Reynolds number and the effect of sound on the transition region of a jet from laminar to turbulent flow. The movement of the reattachment point with sound amplitude is found to be due to changing the location of the transition region.

W-044

Welsh, H. F. (Sperry-Rand Corp.)

FLUID SHIFT REGISTER

U. S. Patent No. 3,201,041 dated August 17, 1965, filed March 23, 1964

This invention relates to shift registers or delay lines of the type employed to store data processing or control systems. This invention provides fluid shift registers wherein the only moving part is the working fluid and only one bistable fluid amplifier element is required for each stage of the register.

W-045

Welsh, H. F. (Sperry-Rand Corp.)

POWER JET CLOCKING

U. S. Patent No. 3,199,781 dated August 10, 1965, filed June 5, 1963

This invention relates to methods and means for clocking or timing the transfer of signals in pure fluid logic systems.

W-046

Weske, J. R.; Rankin, T. M. (University of Maryland)

ON THE GENERATION OF SECONDARY MOTIONS IN THE FIELD OF A VORTEX

University of Maryland, Technical Note BN-313 dated March, 1963

The investigation is concerned with motions in the region of the core of a vortex which exhibit peripheral vorticity. From theoretical reasoning it appears that development of such motions is favored as a zonal maximum of axial vorticity components is produced e.g. by divergence of the vortex core. Several experiments devised to verify theoretical conclusions furnish evidence that concentrations of vorticity periodic about the perimeter actually do occur as expected.

W-047

Westerman, W. J., Jr. (Martin Company, Orlando)

MECHANICALLY ENTRAINED FLUIDIC OSCILLATOR

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. IV, October, 1965

The paper presents the results of an analytical and experimental program aimed at achieving a temperature stable fluid oscillator which is insensitive to relatively low levels of accelerations. Mechanical entrainment of the oscillator frequency by means of a vibrating member is used much in the same manner as the crystal in a crystal controlled electronic oscillator. A mathematical model of the vibrator under the influence of a bianial acceleration environment is presented. A mathematical model of the fluid control devices coupled with the frequency entrainment element is compared to experimental data. An explanation of the operation of the combined oscillator in its preferred configuration is included with photographs of the microminiature test model used in obtaining the data.

W-048

Westerman, William J., Jr.

THE EFFECT OF GEOMETRIC PARAMETERS ON THE STABILITY MARGIN & SWITCHING CHARACTERISTICS
OF PURE FLUID BISTABLE ELEMENTS

Paper - Martin Co., Orlando, Florida

This paper presents experimentally determined design curves relating the
main jet flow and pressure to the control jet flow and pressure necessary for
switching. These curves consist of families relating the wall length, set back,
side wall angle and control port size to gain and stability margins of the device
for various levels of main jet power. The curves allow certain conclusions to be
made regarding the important parameters in the switching phenomena.

W-049

Wetheral, T. G.; Clayton, B. J.

APPLICATION OF PURE FLUID COMPONENTS TO MISSILE CONTROL SYSTEM

Presented to Society of Automotive Engineers Aerospace Fluid Power Systems and
Equipment Committee Thrust Vector Control Panel, April 13, 1964

See Author Clayton, B. J.

W-050

Wetheral, T. G; Byrd, J. L.

DEVELOPMENT OF A PURE-FLUID MISSILE CONTROL SYSTEM

U. S. Army Missile Command Report No. RG-TR-64-18, December, 1964

This report discusses the efforts of the Army Inertial Guidance & Control Lab.
in developing and testing a pure-fluid missile control system, using a modified
Little John Rocket as the Test Instrumentation Missile (TIM). Specific objectives
were to design, fabricate, and test a proportional and bistable amplifier; study
cascaded amplifiers using the water table; evaluate a state-of-the-art six-stage
proportional-pressure amplifier; and fly a test missile with an all-pneumatic roll
control system. Qualitative parametric studies with various amplifier configurations
were conducted until the configuration was fixed. Due to power-jet oscillations,
most of these experiments were difficult to evaluate. A contract with Minneapolis-
Honeywell for the development and fabrication of a missile fluid-control system has
progressed to the flight-test portion of the program.

W-051

Wetheral, T. G.; Atha, L. C. (Redstone Arsenal)

FLUERIC CONTROLS, A DESCRIPTION OF AVAILABLE COMPONENTS AND CURRENT APPLICATIONS

ASME Paper No. 65WA/AUT-21 presented at the Winter Annual Meeting, Chicago, Illinois November 7-11, 1965

A brief introduction to the flueric or fluid amplification field is given. The fundamental physical mechanisms utilized in flueric devices are discussed, and examples of devices which utilize these principles and their characteristics are given. Included are the jet-on-jet amplifiers, vortex devices, boundary-layer control devices, and turbulence amplifiers. A number of aerospace applications presently under investigation or development are described along with the projected advantages for flueric devices. The possible commercial utilization of these elements is briefly discussed. A summary of the advantages/disadvantages and potential improvements for flueric devices is presented.

W-052

White, D. F.; Rodely, A. E.; Chanaud, R. C. (American Radiator & Standard Sanitary Corporation)

A DIGITAL FLOWMETER WITHOUT MOVING PARTS

ASME Paper 65-WA/FM-6 presented at the Winter Annual Meeting Chicago, November 7-11, 1965

W-053

White, D. R.

FLUID FLOW APPARATUS

U. S. Patent No. 2,910,830, November 3, 1959

This invention relates to fluid flow apparatus and more particularly to such apparatus for smoothing a pulsating fluid stream. It is a further object of this invention to provide an improved fluid flow apparatus which can be used in a gas turbine cycle between the resonant combustor and the turbine. In carrying out this invention, in one form , a hollow annular member is positioned adjacent the edges of two opposed hollow spaced tubes or conduits which are axially aligned to provide a fluid flow apparatus.

W-054

White, F. M., Jr.; Ducoffe, A. L.

THE PROBLEM OF PNEUMATIC PRESSURE LAG
PART I - Steady-State Flow in a Tubing System

Paper No. 63--AHGT-6, Transactions of the ASME Journal of Basic Engineering

See Author Ducoffe, A. L.

W-055

White, F. M., Jr.; Ducoffe, A. L.

THE PROBLEM OF PNEUMATIC PRESSURE LAG
PART 2 - Unsteady Flow in a Tubing System Closed at One End

Paper No. 63--AHGT-7, Transactions of the ASME Journal of Basic Engineering

See Author Ducoffe, A. L.

W-056

White, Harry N.

ANALYSIS OF THE STEADY-FLOW PNEUMATIC RESISTANCE OF PARALLEL CAPILLARIES

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, October 26-28, 1965

In this paper an expression is found for the overall pressure drop as a function of volume flow, under conditions of equilibrium, through a pneumatic resister consisting of capillaries in parallel.

The resistance, defined as the overall pressure drop divided by the volume flow, is shown to be a function of the flow, and therefore nonlinear. This nonlinearity is due to an accumulated viscous loss in the entrance of the capillaries and the dissipation of kinetic energy at the outlets of the capillaries.

The analysis is in good agreement with experimental data. It provides a basis for designing resistors of desired values and for reducing the nonlinearity of the resistance.

W-057

White, H. N. (Harry Diamond Laboratories)

FLUERIC PRESSURE REGULATION USING A RESISTANCE SET POINT

Proceedings of the HDL 3rd Fluid Amplification Symposium, Vol. IV, October, 1965

A closed loop feedback control system is described that provides a stabilized pressure notwithstanding variations in the source pressure or the output loading. The system operates about a reference point at which the value of a linear and nonlinear resistor coincide.

W-058

Widell, G. M

VORTEX VALVE

U. S. Patent No. 3,195,303 dated July 20, 1965, filed January 22, 1962

This invention relates to a flow regulating device to control a main flow by a swirling flow. Other objections of this invention are ①To combine at least two swirl chambers to control a high velocity, high temperature flow ② To combine two swirl chambers in such a manner as to increase the range of control afforded by the swirl chambers.

W-059

Wiesner, H. J.; Rüdle, M. A.; Stuttgart, T. H. (Germany)

FLUID DEVICES FOR MACHINE CONTROLS

Paper given at the First Conference on Fluid Logic and Amplification sponsored by the British Hydromechanics Research Association and College of Aeron. Cranfield, England, September 9-10, 1965

W-060

Wille, R.

CONTRIBUTIONS TO THE PHENOMENOLOGY OF FREE JETS

Description of the phenomena in the subsonic stream of free jets. Paper also is concerned with the probelm of turbulence. For downstream from the orifice, free jets have velocity profiles which do not show any longer the origin of the jet from nozzles of different geometrical form. The transition, however, from a velocity profile at the nozzle orifice to the turbulent flow for downstream occurs in different ways.

W-061

Williams III, J. C.; Smetana, F. O.

THEORETICAL STUDY OF A CONVERGENT NOZZLE & FREE JET FLOW

A study to determine the extent to which the flow fields in a small control device could be predicted analytically, and to determine the extent of the losses in the power jet nozzle of such a device. An analysis was made of the flow field in an essentially two-dimensional (width to nozzle height ratio of 50) power jet nozzle consisting of a plenum chamber, contraction region and constant area nozzle. The analysis includes the calculation of the boundary layer growth in the throat, the discharge coefficient, the velocity profiles in the jet, the spreading of the jet and the pressure recovery in a receiver placed in the jet.

W-062

Williams, J E.

REYNOLDS STRESS NEAR A FLEXIBLE SURFACE RESPONDING TO UNSTEADY AIR FLOW

The paper studies the way in which Reynolds stresses near the flow boundary are influenced by surface response. The technique of analysis is based on that developed by Lin (Proc. Nat. Acad. Sciences, 40:741, 1954) to study the Reynolds stresses induced by viscous action in the vicinity of the surface. The technique is generalized to allow for a random-surface motion, such as might be induced by turbulent flow, but the analysis is restricted to a two-dimensional surface profile.

W-063

Williams, J. G.; Byrd, J. L.; Clayton, B. J.

DEVELOPMENT OF PURE FLUID MISSILE CONTROL SYSTEM (SUMMARY REPORT FY 62)

U. S. Army Missile Command Report No. RG-TR-62-7, October 28, 1963

    See Author Byrd, J. L.

W-064

Wilson, James N.

FLUID AMPLIFICATION: 13. FLUID ANALOG TO DIGITAL CONVERSION SYSTEM

DDC Report AD-613704 (Case Institute of Tech. Report for Contract DA 49 186AMC79D, December, 1964

    The design and development of a fluid analog to a digital conversion system are described. The system represents the digital portion of an incremental fluid control system and consists of a fluid quantizer, directionsensing circuit and four-stage binary bidirectional counter. The system operates at over 100 pulses per second. A method of quantizing an analog quantity, using a fluid as the information transmission medium, is examined and evaluated. The design of suitable fluid logic elements is described.

W-065

Wilson, J. N.; Orner, P. A.

FLUID STATE HYBRID CONTROL SYSTEMS

    See Author Orner, P. A.

W-066

Winston, E. T.; Hawes, P.; Katz, S.

THE RESPONSE OF A BISTABLE FLUID AMPLIFIER TO A STEP INPUT

    See Author Katz, S.

W-067

Wood, D. E.; Rivest, E. L.; Dodson, G. C. (General Electric Co.)

SIGNAL PROCESSING AND WAVEFORM PATTERN RECOGNITION FOR -- ANALYSIS OF SIGNAL
ORIGINS, INSTRUMENTATION AND AUTOMATION

G. E. TIS Report 65-C-041 dated September 14, 1965

Signal Processing in the sonic and acoustic range is opening up a new field
of technology and business opportunity in advanced instrumentation and automatic
equipment. To accomplish this, talents from many diverse disciplines are teaming
their efforts in the "Analysis Stage" to draw relationships between signal parameters
and the signal source characteristics. In the "Mechanization Stage" their results
are used to create the automatic analyzing equipment for such futuristic applications
as detecting incipient malfunctions in machines, recognizing speech for computer
input and advancing sonar system technology. While citing examples from real-time
spectral analysis, cases, considerable weight is given optical processing systems for
the future.

W-068

Wood, O. Lew (Sperry, Utah)

DESIGN GUIDE PURE FLUID DEVICES

Machine Design, June 24, 1965, Vol. 37, Pages 153-180

To date, development of pure fluid devices and systems has been primarily on
an empirical basis. This reflects the difficulty of mathematically analyzing steady-
state device operation, and the formidable problems encountered in representing
transient phenoma. Recently, significant progress has been made toward the time
dependent solution of the Navier-Stokes fluid-flow equations by using numerical
analysis techniques with a relatively large electronic computer. This report
gives a complete detailed report on both active and passive elements, sensors,
fabrication and testing and applications.

W-069

Wood, O. Lew

DITHERING JET OVERCOMES STICTION IN A HIGH-SPEED FLUID AMPLIFIER

As fluid devices move from the R&D stages into commercial use, two characteristics have tended to limit their usefulness. (1) Switching time is much slower than for analogous electronic devices. This is the time interval, after the initiation of the control signal, beginning when the changing control signal reaches 50 per cent of its final value and ending when the subsequently switched output signal reaches 50 per cent of its value (2) Interaction effects limit the number of units that can be interconnected. One solution resulting from the current Sperry-Utah development efforts to overcome these two limitations is the edgetone amplifier. This article presents a description of its operating principles.

W-070

Wood, O. Lew; Fox, Harold L.

FLUID COMPUTERS

See Author Fox, Harold L.

W-071

Woodward, K. E.

FLUID AMPLIFIER

This invention relates generally to fluid amplifiers which utilize the flow of a fluid so that a control input fluid signal is amplified.

W-072

Woodward, Kenneth E.; Barila, Timothy (Walter Reed Army Institute of Res); Joyce, James; and Mon, George (Harry Diamond Lab)

FLUID AMPLIFIER-CONTROLLED MEDICAL DEVICES

Proceedings of the 17th Annual Conference - Engineering in Medicine & Biology

See Author Barila, T.

W-073

Woodward, K. E.

FLUID OSCILLATOR

This invention relates generally to a fluid system for oscillating a piston in which the movement of the piston generates fluid pulses. These pulses ultimately determine the rate of oscillation of the piston and accordingly the output of the system.

W-074

Woodward, Kenneth; Mon, George; Joyce, James; Straub, Henry (Harry Diamond Lab.)

FOUR FLUID AMPLIFIER CONTROLLED MEDICAL DEVICES

Proceedings of the HDL 2nd Fluid Amplification Symposium, Vol. IV, May 26-28, 1964

The fluid amplifier provides a solution for certain design problems associated with modern military medicine. The military requires its medical equipment to possess not only a reliability and life compatible with its proposed use, but sufficient ruggedness to withstand the rigors of logistics and operation in the field. The equipment must be lightweight. Pneumatically powered devices should be able to tolerate fairly high degrees of contamination in the power fluids without malfunctioning. Repeated autoclaving of appropriate portions of the apparatus should not degrade its function.

Where fluid amplifiers are used, these requirements are generously satisfied. By reducing the number of moving parts involved, logistics problems are simplified and manufacturing cost reduced.

W-075 (IBM Corp.)

SOME DESIGN TECHNIQUES FOR FLUID-JET AMPLIFIERS

    The operation of the fluid-jet amplifier is described briefly. A performance criterion is developed for the amplifiers, and design techniques are presented which constrain the amplifier to exhibit the decision function. The techniques involve the superposition of a bias on the amplifier which alter its switching characteristics. In addition, a stability criterion for amplifier operation is developed and its uses are suggested. Some effects of internal geometry variations are also discussed.

Y-004

Yang, Kwang - TZY; Kelleher, M. D.

ON HYDRODYNAMIC STABILITY OF TWO-DIMENSIONAL UNSTEADY INCOMPRESSIBLE LAMINAR BOUNDARY LAYERS

A linearized hydrodynamic stability theory for unsteady incompressible laminar boundary layers over arbitrary cylinders is described. Criteria based on the instantaneous rate of change of the disturbance energy are introduced. In order to apply these criteria to a given unsteady laminar boundary-layer problem, it is necessary to have a complete knowledge of the instantaneous disturbance-amplitude functions. It is found that these disturbance-amplitude functions are governed by a partial differential equation, which can be solved by a numerical iteration scheme. Successive iterations are then obtained by solving an inhomogeneous ordinary differential equation repeadly at the same time instants. Two numerical examples are calculated. One deals with unsteady flow over a flat plate when the free-stream, initially steady, undergoes a step-wise change in its velocity to one and one-half times of its original value. The second example treats an unsteady stagnation flow with its free-stream velocity, initially again steady, undergoing deceleration first and then changing to acceleration.

Y-005

Young, F. J.; Angrist, S. W.; Osterle, J. F.; Rouleau, W. T.

UNCONVENTIONAL METHODS FOR INFLUENCING FLUID FLOW

See Author Osterle, J. F.

Y-006

Young, J.

TOMORROW'S CONTROLS - FLUID AMPLIFIERS CAN OUST ELECTRONICS

Pure fluid amplifier operates without moving parts and is either wall-attachment or turbulent-jet type; former is based upon Coanda effect, i.e. property of fluid to remain attached to given surface until forcibly detached; amplifier is equivalent of electronic flip-flop element and has capacity for memory; design of binary counter is given as example; turbulent jet amplifiers are used for extremely accurate sensing equipment; automatic bottling plant in operation for some time has successfully utilized fluid amplifiers to control bottling line.

Y-007

Young, J. E. R.

FLUID CONTROL DEVICE

An otherwise conventional fluid amplifier is controlled on the principle of the ion drag pump, by electrical signals. Ions injected into a fluid are transported through the fluid by application of a high-electrical field. The viscous drag on the ions produces a pressure gradient in the fluid. This effect is used to control the switchover of the main jet of the amplifier.

Z-008

Zakkay, V.; Krause, E.

THE RADIAL VARIATION OF THE EDDY VISCOSITY IN COMPRESSIBLE TURBULENT JET FLOWS

DDC Report AD617701 (New York University Report for contract AF33615-1516, May, 1965)

Z-009

Zalmanzon, L.

PNEUMATIC COMPUTING AND CONTROL DEVICES

IAA Report A64-16959, Also Academy of Sciences, Inst. of Automatics and Telemechanics, MOSCOW, USSR/Engineering Materials and Design, Vol. 7, April, 1964 Pages 228-232, IAA Report No. A64-16957

Survey of developments in the field of pneumatic and hydraulic jet devices at the USSR'S Institute of Automation and Telemechanics. Aerodynamic principle of jet element design, characteristics of the simple jet element, jet element amplifiers, logic operations, signal storage cells, aerodynamic oscillators and printed circuitry are among the topics discussed. (9 Rx. cited).

Z-010

Zappanti, Anthony J.

GAS SEPARATION IN A VORTEX

DDC Report AD-604 832 (Air Force Inst. of Tech. Wright-Patterson AFB) Master's Thesis, May, 1964

The ability of a gaseous vortex to contain a foreign gas within the core was evaluated. Carbon dioxide was injected axially, from exit to entrance, into the core of a vortex created by tangential injection of air into a vortex chamber. A suction tube in the back wall of the chamber was used to obtain the mixture in the core for chemical analysis. Carbon dioxide concentration in the core was measured at varying points of injection for vortex tube diameters of 1, 1 1/2, and 2 inches. Tests were conducted for four different flow rates of the vortex.

It was found that carbon dioxide concentration decreased rapidly with axial distance from the point of injection, and maximum concentration at a given point generally decreased with an increase in the ratio of air mass flow to vortex tube diameter.

Z-011

Zarek, J. M.; Earles, S. W. E.

REFLECTION OF PRESSURE WAVES AT SHARP-EDGED ORIFICES

See Author Earles, S. W. E.

Z-012

Ziemba, R. T.; Kantola, R. A.

FLUID TIMER FOR ORDNANCE APPLICATIONS

See Author Kantola, R. A.

Z-013

Ziemba, R.; Avery, H. W.; Kantola, R. A.

FLUID TIMER FOR ORDNANCE APPLICATIONS

See Author Avery, H. W.

Z-014

Zilberfarb, S. N., Polter, E. M. (Sperry-Rand)

PURE FLUID VELOCITY MODULATED AMPLIFIER

U. S. Patent No. 3,182,675 dated May 11, 1965, filed November 17, 1961

This invention relates to pure fluid devices, and more particularly to one wherein an impinging control stream shifts the power stream in a direction other than the direction of the control stream.

Z-015

Zilberfarb, S. N. (Sperry-Rand)

SEQUENTIAL FLUID AMPLIFIER

U. S. Patent No. 3,124,160 dated March 10, 1964, filed June 29, 1962

This invention relates to a multi-stable fluid amplifier having a sequential switching operation and more particularly, to one wherein the switching is independent of the channel location of the main power stream.

Z-016

Zingg, R. H.; Glaettli, H. H.; Müller, H. R.

REMARKS ON THE LIMITATIONS OF PURE FLUID ELEMENTS

See Author Glaettli, H. H.

Z-017

Zingg, R. H. W.; Mitchell, A. E.; Müller, H. R.

SOME RECENT DEVELOPMENTS IN THE DESIGN OF FLUID SWITCHING DEVICES AND CIRCUITS

See Author, Mitchell, A. E.

Z-018

Zisfein, M. B.; Curtiss, H. A.

A HIGH GAIN PROPORTIONAL FLUID STATE FLOW AMPLIFIER

Proceedings of the HDL Fluid Amplification Symposium, Vol. I, May 26-28, 1964

During the past three years the authors and their associates have been engaged in the invention, design and development of a new generation of high performance analog fluid state components. These efforts have dealt with all facets of the cybernetic loop. encompassing sensors, amplifiers, logic and compensation devices, and actuators; the ultimate objectives being the combination of these into advanced fluid state systems.

Z-018 (Continued)

Zisfein, M. B. & Curtiss, H. A.

A HIGH GAIN PROPORTIONAL FLUID STATE FLOW AMPLIFIER

This paper deals with our development of components for mass flow amplification. These high gain flow amplifying components of ours are almost completely analogous to the electronic transistor in that the input of a control flow (current) is able, over a broad frequency band, to modulate a much larger flow fed from a supply reservoir so that it becomes an output flow which follows faithfully the time variant fluctuations of the small input control flow. We will define first the overall nature of this flow amplification and then the configurations and hardware with which it is accomplished.

Z-019

Zisfein, M. B. (Giannini Controls)

THE APPLICATION OF FLUID-STATE DEVICES TO PROCESS CONTROL COMPUTATION

ASME Paper No. 65-WA/PID-11 presented at the Winter Annual meeting, Chicago, Illinois, November 7-11, 1965

The paper begins with an introduction leading to a general description and discussion of analog and digital fluid-state components and systems, particularly those which may be of pertinence to the process-control field. An illustration of a working fluid-state analog computer is presented. This computer is the Giannini Controls Corporation Fluid-State Ratio Computer which embodies such unique elements as a fluid-state inverter, a two-variable fluid-state multiplier, plus related fluid-state components and subsystems. The design and development of this system and its components is described, and its performance curves are presented. Today's fluid-state technology is then extrapolated to illustrate a number of process-control computations which can be performed by present and future fluid-state devices and systems.

Z-020

Zumwalt, Glen W.; Jackomis, William N.

AERODYNAMIC THROAT NOZZLE FOR THRUST MAGNITUDE CONTROL OF SOLID FUEL ROCKETS

ARS Journal, Volume 32, Number 12, Pages 1934-1936, December, 1962

See Author Jackomis, William N.

Z-021

Zumwalt, G. W.; Walker, W. F. (Oklahoma State University)

THE ANALYSIS OF SUBMERGED JET FLOW FIELDS BY A NUMERICAL FIELD COMPUTATION METHOD

The fluid mechanics of fluid amplifiers has proven to be discouragingly difficult to analyze. Some special solutions have been obtained and insight has been gained by these into the phenomena involved, but generally, the flows and geometries are too complex to calculate. This is not surprising. Typical fluid control devices contain separated and reattaching flows, turbulent boundary layers and mixing regions, cross-moving streams, complex wall geometries, and all this inside bounding walls and receivers which impose pressure gradients in all directions.

To these difficulties we generally bring the methods developed in boundary layer studies. Since such a wealth of background work exists in the analysis of boundary layers (both guided and separated), it was natural that fluid amplifier studies should attempt to draw upon this fund. However, one does not work long at this before severe limitations in conventional fluid dynamics approaches are seen:

(1) The flow models generally call for a large potential flow region to impress a pressure field upon the viscous regions.

(2) Small aspect ratios turn most problems into three-dimensional ones.

(3) The non-linearity of the equations forces one to seek overall-effects type solutions by integral methods.

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